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J. F. KELLY, Editor

CONTENTS

Volume VI. JULY, 1929 Number VII.

Official Opening of the Twenty-fifth Annual Convention of the Association of Iron and Steel Electrical Engineers and Iron and Steel Exposition—By James A. Farrell, President, United States Steel Corporation..... II

List of Manufacturers who participated in the Iron and Steel Exposition..... IV

Special Study Regarding Lubrication of Anti-Friction Bearings on Mill and Crane Motors—By Special Committee on Bearings of the A.I.& S.E.E. F. D. Egan, Chairman 415

Surveys of Lighting and Voltage in the Steel Industry—By Samuel G. Hibben 418

Correction—Electric Welding Report of the A.I.&S.E.E. 422

Results of the Election of Officers for the year 1929-30 of the A.I.&S.E.E... 422

Symposium—

Blast Furnace Gas Cleaning—

By W. J. McGurty..... 424

By C. W. Hedberg..... 426

Discussion—Presented by H. C. Siebert, Gordon Fox, J. C. Hayes, F. E. Leahy, S. G. Worton, R. S. Coulter, L. E. Riddle, T. A. Lewis, L. J. Reed, Walter de Fries, A. C. Cummins, R. M. Hussey, I. A. Nicholas, J. E. Dunn and W. B. Chapman..... 431

New Blast Furnace Power Plant—Fairfield Works, Tennessee Coal, Iron and Railroad Company—By J. M. Sprague 440

The Application of 300 Series Ball or Roller Bearings to Westinghouse Mill Type Sleeve Bearing Motors—By J. L. Brown 448

Items of Interest..... 450

List of Advertisers..... VI

Published Monthly by

Association of Iron and Steel Electrical Engineers

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Mr. James A. Farrell, President United States Steel Corporation, who opened the Twenty-fifth Annual Convention and Exposition of the Association of Iron and Steel Electrical Engineers by an engineering feat (for the first time) using radio to make electricity respond to the command of the human voice.

Teck. 50

EDITORIAL

25th Convention and Exposition

ASSOCIATION OF IRON & STEEL ELECTRICAL ENGINEERS

JUNE 17, 18, 19, 20, 21, 1929

PITTSBURGH, PA.

Over ten thousand interested visitors, chiefly executives and operators of the Iron and Steel Industry took part in the various activities of the Convention and Exposition held in Pittsburgh, Pa., June 17th to the 21st, 1929.

This Convention and Exposition was by far the greatest technical event in the history of the Iron and Steel plants, all of the activities were held under one roof with the exception of the inspection trip to the Jones & Laughlin Steel Corporation plant at Aliquippa, which required twelve railroad coaches to handle the crowd.

Twenty-one papers prepared by engineering authorities were presented before the various technical sessions, and the discussions indicated the advances being made in the various engineering arts with special reference to Steel Plants.

One of the most pleasing and one of the most interesting features in connection with the Convention and the Exposition was the unique manner of its official opening. Mr. James A. Farrell, President of the United States Steel Corporation opened the Convention and Exposition with a message as follows:

Members of the Association of Iron and Steel Electrical Engineers:

It is with no small measure of personal satisfaction and sense of honor conferred, that I take advantage of your invitation to say a few words at the opening of your convention, and though I regret keenly that I am unable to be with you in person, it is with a sense of admiration for the attainments of your profession that I am able to address your body assembled in the William Penn Hotel in Pittsburgh from my office at 71 Broadway, New York City.

The steel industry can justly take pride in the progress it has made, and as an essential factor making such progress possible, it acknowledges and appreciates as an important factor of its organization, your Association of Iron and Steel Electrical Engineers, representing as it does, the iron and steel plant electrical engineers of the United States, Canada and many foreign countries. The application of the principles and appliances of electricity to industry has been phenomenal in its growth, and it is gratifying to know that through the endeavor of electrical engineers, the adaptation of intricate electrical apparatus to the severe requirements of steel plant use has kept pace with that growth. Your Association, in the gathering and dissemination of knowledge and experience in this particular field, has been invaluable, and may I take this opportunity of complimenting you on your achievements and wishing you continued success in your work.

The ramifications of industry are varied and vast, and opportunity to come in direct contact with any number of our fellow workers is but seldom afforded. I am informed that the proceedings of this meeting are being broadcast from a radio station in your city, so may I presume upon your kindness to take time to extend a personal greeting to my fellow workers in our industry who may be listening in.

In closing my remarks I have been asked to say a few magical words. I say magical, because the words I will say here in New York into this microphone will automatically start a miniature electric train placed in the lobby of the William Penn Hotel in Pittsburgh, more than 300 miles away. They tell me that when I give the signal, the small train will start—that my words here in New York will throw the switch and turn on the electric power.

I am now ready to give the command to this so-called Robot engineer.

Are you ready for the signal?

"Now go ahead."—"Stop."—"Back up."—"Stop."—"Go ahead again."

Gentlemen, I thank you for the privilege of saying these few words of greeting to you and of having participated in this unique means of officially opening your convention.

LIST OF EXHIBITORS AT IRON AND STEEL EXPOSITION

WILLIAM PENN HOTEL PITTSBURGH, PA.

June 17, 18, 19, 20, 21, 1929

Name	Booth	Floor	Room
Air Reduction Sales Co.	143-144	First	Exhibition Hall
Ajax Electrothermic Corp.	113	17th	Corridor
Aluminum Co. of America	79-80	17th	Cardinal Room
The Alliance Machine Co.	200	First	Exhibition Hall
Allis Chalmers Mfg. Co.	156-157	First	Exhibition Hall
Appleton Electric Co.	17	17th	Major Ball Room
Atlas Car & Mfg. Co.	207-208	First	Exhibition Hall
Automatic Reclosing-Circuit Breaker Co.	4	17th	Silver Salon
Automatic Transportation Co.	147	First	Exhibition Hall
Babcock & Wilcox Co.	145	First	Exhibition Hall
Baker-Raulang Co.	155-170	First	Exhibition Hall
Bartlett-Hayward Co.	36-37	17th	Reception Room
Earl B. Beach Co.	75	17th	Cardinal Room
Bell Telephone Company of Pennsylvania	69	17th	Cardinal Room
Benjamin Electric Co.	74	17th	Major Ball Room
Wm. A. Bittner Co.	149	First	Exhibition Hall
Blaw Knox Co.	189	First	Exhibition Hall
Bristol Co.	184	First	Exhibition Hall
Brown Instrument Co.	116	17th	Main Corridor
Bull Dog Electric Products Co.	117	17th	Main Corridor
Bussmann Mfg. Co.	11	17th	Major Ball Room
Century Electric Co.	181	First	Exhibition Hall
Centrifix Corporation	210	First	Exhibition Hall
Clark Controller Co.	53-54	17th	Reception Room
Clark Tructractor Co.	209-C	First	First Corridor
Cleveland Crane & Eng. Co.	201	First	Corridor Space
Colts Patent Fire Arms Mfg. Co.	20	17th	Silver Salon
Combustion Engineering Corp.	152	First	Exhibition Hall
Crocker-Wheeler Elec. Mfg. Co.	73-73½	17th	Interior Corridor
Crouse-Hinds Co.	23-39	17th	Reception Room
Cutler-Hammer, Inc.	42-43	17th	Major Ball Room
De Bothezat Impeller Company	99	17th	Major Ball Room
De Laval Separator Co.	94	17th	Blue Room
Delta Star Electric Co.	204	First	Exhibition Hall
M. H. Detrick Co.	194	First	Exhibition Hall
De Walt Products Corporation	202	First	Exhibition Hall
Joseph Dixon Crucible Co.	82	17th	Cardinal Room
Dot Lubricating Co. of Pgh.	27	17th	Major Ball Room
Doubleday-Hill Electric Co.	9	17th	Major Ball Room
Duquesne Light Co.	125	17th	Main Corridor
Economy Fuse & Mfg. Co.	58	17th	Major Ball Room
Edison Storage Battery Co.	24	17th	Silver Salon
Electric Controller & Mfg. Co.	28-29-44-45	17th	Major Ball Room
Electric Journal	122	17th	Main Corridor
Electric Machinery Mfg. Co.	180	First	Exhibition Hall
Electric Service Supplies Co.	166	First	Exhibition Hall
Elliott Company	89	17th	Blue Room
Erie Malleable Iron Works	64	17th	Major Ball Room
Fafnir Bearing Co.	205	First	Exhibition Hall
Fairbanks-Morse Co.	185-186	First	Exhibition Hall
Fort Pitt Steel Casting Co.	114	17th	Main Corridor
Frigidaire Corporation	217-A, 218-A	17th	Blue Room
Foley Saw Tool Co.	96	17th	Blue Room
Foxboro Company	5	17th	Interior Corridor
General Electric Co.	30-31-32-46-47-48	17th	Major Ball Room
General Electric Supply Co.	34	17th	Major Ball Room
Great Western Fuse Co.	111	17th	Main Corridor
Henrite Products Co., Inc.	112	17th	Main Corridor
Jno. D. Hiles Co.	150-151	First	Exhibition Hall
The Hodson Corp.	18	17th	Major Ball Room
Homestead Valve Mfg. Co.	140	First	Exhibition Hall
Hyatt Roller Bearing Co.	62-63	17th	Major Ball Room
Ideal Commutator Dresser Co.	52	17th	Silver Salon
I-T-E Circuit Breaker Co.	121	17th	Main Corridor
Ivanhoe Division Miller Co.	77	17th	Cardinal Room
Industrial Engineering	7	17th	Silver Salon
Jefferson Electric Co.	51	17th	Silver Salon
Johns-Manville, Inc.	67	17th	Reception Room
E. J. Lavino Co.	167	First	Exhibition Hall

LIST OF EXHIBITORS AT IRON AND STEEL EXPOSITION

Name	Booth	Floor	Room
W. G. Kerr & Co.	206	First	Exhibition Hall
Keystone Lubricating Co.	55-56	17th	Reception Room
Kier Fire Brick Co.	78	17th	Cardinal Room
J. Frank Lanning Co.	18	17th	Major Ball Room
Lebanon Steel Foundry	197	First	Exhibition Hall
Le Carbone Brush Co.	120	17th	Main Corridor
Lincoln Electric Co.	191-192	First	Exhibition Hall
Manning Maxwell & Moore (Shaw Crane Div.)	50	17th	Major Ball Room
Martindale Electric Co.	60	17th	Major Ball Room
Mesta Machine Co.	187	First	Exhibition Hall
Metal & Thermit Corp.	199	First	Exhibition Hall
Metropolitan Device Corp.	70	17th	Parlor B-C
Mica Insulation Company	149	First	Exhibition Hall
Michigan Steel Casting Co.	198	First	Exhibition Hall
Monitor Controller Co.	154-158	First	Exhibition Hall
Morgan Engineering Co.	190	First	Exhibition Hall
Morse Chain Co.	6	17th	Silver Salon
Henry N. Muller Co.	25-41	17th	Major Ball Room
National Air Filter Co.	92	17th	Blue Room
National Safety Council	90	17th	Blue Room
National Carbon Co.	38	17th	Silver Salon
National Electric Products Co.	13-14	17th	Major Ball Room
New Departure Mfg. Co.	148	First	Exhibition Hall
Nichols Lintern Co.	66	17th	Major Ball Room
Norma Hoffmann Bearings Corp.	15	17th	Major Ball Room
Nukem Products Corp.	93	17th	Blue Room
Ohio Electric & Controller Co.	188	First	Exhibition Hall
Ohio Steel Foundry Co.	81	17th	Cardinal Room
Okonite Company	26	17th	Major Ball Room
Orange Roller Bearing Co.	84	17th	Cardinal Room
Otis Elevator Co.	203	First	Exhibition Hall
Penna. Lubricating Co.	130	17th	Interior Corridor
Permutit Company	12	17th	Major Ball Room
Pittsburgh Electric Furnace Corp.	119	17th	Main Corridor
Pittsburgh Elec. & Machine Works	8	17th	Major Ball Room
Pyle-National Co.	57	17th	Silver Salon
Pyrometer Instrument Co.	153	First	Exhibition Hall
Penna. Natural Gas Men's Association	115	17th	Main Corridor
Reed Air Filter Co.	159	First	Exhibition Hall
Reading Chain & Block Corp.	171	First	Exhibition Hall
Wallace M. Reid & Co.	83	17th	Cardinal Room
Reliance Electric & Eng. Co.	163-164-178-179	First	Exhibition Hall
Republic Flow Meters Co.	95	17th	Cardinal Room
H. Lee Reynolds Co.	141-142	First	Exhibition Hall
Roller Smith Co.	61	17th	Major Ball Room
Rollway Bearings Co., Inc.	3	17th	Interior Corridor
Rotor Air Tool Co.	87	17th	Blue Room
Rowan Controller Co.	65	17th	Major Ball Room
Rutherford & Uptegraff	1-2	17th	Parlor B-C
S.K.F. Industries, Inc.	172-173	First	Exhibition Hall
The T. L. Smith Co.	97	17th	Blue Room
Square D. Co.	40	17th	Silver Salon
Standard Auto-Tite Joints Co.	193	First	Exhibition Hall
Standard Underground Cable Co.	33-49	17th	Major Ball Room
H. S. Stockdale Co.	16	17th	Major Ball Room
Syntron Company	165	First	Exhibition Hall
Shenango-Penn Mold Co.	195-196	First	Exhibition Hall
Texas Company	85	17th	Cardinal Room
Thompson Electric Co.	76	17th	Cardinal Room
Timken Roller Bearing Co.	21-22	17th	Parlor-D
Tippins & Sprengle, Inc.	146-C	First	1st Floor Corridor
Tool Steel Gear & Pinion Co.	71-72	17th	Cardinal Room
Harold E. Trent Co.	123	17th	Main Corridor
Trico Fuse Mfg. Co.	149	First	Exhibition Hall
Trumbull Electric Mfg. Co.	168-169	First	Exhibition Hall
Union Electric Mfg. Co.	35	17th	Silver Salon
United States Graphite Co.	10	17th	Major Ball Room
V. V. Fittings Co.	59	17th	Major Ball Room
The Weaver Bros. Co.	58	17th	Major Ball Room
West Penn Electric Co.	19	17th	Silver Salon
Westinghouse Elec. & Mfg. Co.	160-161-162-175-176-177	First	Exhibition Hall
Geo. D. Whitcomb Co.	174	First	Exhibition Hall
Edwin L. Wiegand & Co.	124	17th	Main Corridor
L. J. Wing Mfg. Co.	109	17th	Main Corridor
Daniel Woodhead Co.	98	17th	Blue Room
Yale & Towne Mfg. Co.	182-183	First	Exhibition Hall

INDEX TO ADVERTISERS

A

Alliance Machine Company 495
Allis Chalmers Mfg. Co. 484
Aluminum Company of America 477
American Gas Association 472

B

Bartlett Hayward Company 452–508
Blaw Knox Company 514
Baker Raulang Company 474
Benjamin Electric Mfg. Co. 501
E. W. Bliss Company 457
H. A. Brassert & Co. 458
Bull Dog Electric Prod. Co. 526

C

Chapman Stein Company 479
Clark Controller Company 469
Cleveland Crane & Engineering Co. 517
Colts Patent Fire Arms Mfg. Co. 510
Combustion Engineering Corp. 453–503
Crocker Wheeler Elec. Mfg. Co. 527
Crouse Hinds Company 461
Cutler Hammer, Inc. 455–473–505

D

DeLaval Steam Turbine Company 489–493
Delta Star Electric Company 492
M. H. Detrick Company 528
Doubleday Hill Electric Co. 492

E

Economy Fuse & Mfg. Co. 498
Electric Controller & Mfg. Co. 481
Electric Machinery Mfg. Co. 500
Electric Engineers Equipment Co. 496
Electric Power Equipment Co. 486
Electro Dynamic Co. 504

F

Farrel Birmingham Co., Inc. 475
Franklin Electric & Construction Co. 493

G

General Electric Company Cover–4–523
Graybar Electric Company 488

H

George J. Hagan Company 522
Harnischfeger Corp. 483
Hyatt Roller Bearing Company 513

I

International Nickel Company 471
Iron City Electric Company 494
ITE Circuit Breaker Company ..... Cover 3

J

Johns Manville, Inc. 499

K

Keystone Lubricating Co. 518

L

Lapp Insulator Company 460

M

Martindale Electric Company 485
Moloney Electric Company 494
Morgan Construction Company 462
Morgan Engineering Company 520
Morganite Brush Company 491

N

National Air Filter Company 511
National Carbon Company, Inc. 478
New Departure Mfg. Company 524
Nichols Lintern Company 454
Norma Hoffmann Bearings Corp. 521

O

Ohio Electric & Controller Co. 466
Okonite Company 459

P

Penn Union Electric Corp. 515
B. F. Perkins & Sons, Inc. 491

R

Railway & Industrial Engineering Co. 512
Reed Air Filter Company 456
Reliance Electric & Engineering Co. 516
Research Corp. 464
Rockbestos Products Corp. 480
Roller Smith Company ..... Cover 1
Rowan Controller Company 490

S

Selden Company 467
Sharples Specialty Company 470
Shepard Niles Crane & Hoist Corp. 476
SKF Industries, Inc. 502
Smith and Serrell 496
Stackpole Carbon Company 506
Standard Underground Cable Company 468

T

Thompson Electirc Company 488
Timken Roller Bearing Company 507
Tool Steel Gear & Pinion Company 495
Trico Fuse Mfg. Company 482

U

Union Electric Mfg. Company 489
R. E. Uptegraff Mfg. Co. 497

V

V. V. Fittings Company 487

W

Westinghouse Electric & Mfg. Co. Cover 2–463–509–519
Weston Electrical Instrument Co. 490
Edwin L. Wiegand Company 465
Geo. D. Whitcomb Co. 525

*Special Study Regarding Lubrication of Anti-Friction Bearings on Mill and Crane Motors**

By Special Committee on Bearings,
Association of Iron and Steel Electrical Engineers

F. D. EGAN, Chairman,

In response to a questionnaire, which has been circulated in the steel industry, through the membership of the A. I. & S. E. E. in general practice followed in the lubrication of Anti-Friction bearings, a large number of replies have been received†, which are summarized in the following tabulation in an effort to determine some definite practice to follow out in the lubrication of Ball and Roller Bearings. In general, the replies indicate a wide diversity of opinion on the subject and make it almost impossible to formulate a definite set of rules to suit all conditions. This study will be continued.

QUESTIONNAIRE AND REPLIES

Question No. 1—How often should Ball or Roller bearings in Mill Motors be lubricated when operating under more or less normal conditions.

To this question, replies were of the following nature:

5 Replies—Indicated every three months.
1 Reply —2 to 10 times per year, depending on installation.
1 Reply —Up to 300 R.P.M.—Annually.
300 to 500 R.P.M.—2 to 3 times per year.
500 to 800 R.P.M.—Monthly.
800 to 1000 R.P.M. Semi-Monthly.
1000 to 1500 R.P.M.—Weekly.
3 Replies—Once a year.
5 Replies—Once a month.
3 Replies—Three to six months.
1 Reply —Depends on size of bearing—Inspect every month.
7 Replies—Every six months.
1 Reply —As needed—No rule.
2 Replies—Every two weeks.
2 Replies—Weekly.
1 Reply —Once or twice each turn.
1 Reply —Depends on condition.
1 Reply —Once or twice per year.
1 Reply —Every five or six months.
1 Reply —Every two or three months.
1 Reply —Six months—Hot places nine weeks.
2 Replies—Every four months.
1 Reply —Six months to one year.
1 Reply —As indicated by frequent inspection.
1 Reply —Six to eight months.

In this instance, the majority of replies indicate from three to six months intervals is sufficient for lubrication of Anti-Friction Bearings in normal operation.

Question No. 2—How much grease should be added when motors are lubricated? Is there any definite way of determining how much grease to add and at what intervals?

2 Replies—Fill with gun from lower grease hole until grease is seen at upper grease hole.
1 Reply —Best practice to clean out bearing from two to four times a year and refill with new lubricant.
3 Replies—Bearing should never be filled more than half full; no way to determine how much grease to add.
1 Reply —Bearing should be filled with grease to 1/3 its capacity and not more than ½ full. You may find its capacity by measuring the cavity by best means available and lubricating at intervals as specified under Question No. 1. The best method of measuring grease for these bearings has been found by taking a hand grease gun that has adequate capacity and notch or mark the screw stem by ounces and the attendant will know how many ounces of grease to put in each bearing from the tag that is on the bearing, indicating how many ounces of grease per one shot and intervals.
1 Reply —Depends on workman's judgment and grease leakage.
1 Reply —Speed not over 1800-Bearing not larger than 314 fill housing.
4 Replies—Depends on operating conditions and oiler.
1 Reply —The least amount, present bearings do not show how much to add, nor can you tell when you have enough.
1 Reply —Varying quantities—No way to tell how much.
1 Reply —Fill housing 1/2 to 2/3 full but never full, to determine height use gage oil center of bottom ball or roller.
1 Reply —Wash out with benzine and oil, repack with new lubricant and seal.
1 Reply —Enough lubricant should be added to cover lower race of bearing. Once a year the old lubricant should be thoroughly flushed out and a fresh measured supply put in. This can be done with a gun or compressor.
1 Reply —Fill the bearing to overflows.
3 Replies—No positive way.
4 Replies—Depends on size of bearing.
1 Reply —In general, we have found it unnecessary to add any lubricant during the first two years.
2 Replies—One turn of grease cup. No, except by feel of bearing and experience.
1 Reply —Design bearing so grease level can be checked. Cover bottom roller.
1 Reply —Two squirts from gun. Only by inspection.
1 Reply—Somewhat less than enough to fill housing. Can only be determined by inspection.
2 Replies—Two or more turns on gun or cups, depending on size.
1 Reply —Fill with grease to ¼ the capacity of housing. No definite way to tell how much.
1 Reply —Eight ounces will take care of average motor.
1 Reply —Add one tablespoon at each greasing in most cases. A few may require more, but if such is the case, it is well to check felt seal.
1 Reply —Keep housing ¼ to ¾ full. Amount and intervals determined by experience.
1 Reply —Add ½ the initial amount put in bearings.

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*Presented before Twenty-fifth Convention A. I. & S. E. E., June, 1929.

†About 65% of the Steel Mill tonnage represented in these replies.

The nature of replies to this question is so diversified, as to make it practically impossible to formulate a set rule, for the most part, however, present day design in roller bearing housings does not provide any means of determining how much lubricant is present in the bearings, without disassembling cartridge and operating experience is the only guide for adding more lubricant.

Question No. 3—Should the frequency of lubrication be increased when motors are working under abnormal conditions, such as subject to heat from outside source; or should this condition be taken care of by a different grade of grease?

18 Replies—Same time but different grease.
1 Reply —Either of both depending on conditions.
1 Reply —No. Proper grease will take care of heat condition.
1 Reply —Conditions should be checked.
12 Replies—Increase frequency and use different grease as well.
4 Replies—Increase frequency.
1 Reply —One grease should answer.
1 Reply —Requires more frequent attention.
1 Reply —If grease runs from bearing, they should be greased as often as required, to keep bearings full.
1 Reply —Use grease recommended by Bearing Co. and apply it more often.

In this instance, the majority of replies indicate a different grade of grease should be used and bearing should be lubricated more frequently than under normal operating conditions.

Question No. 4—To what extent is grease leakage experienced?

20 Replies—Very little if proper maintenances is given to seal.
1 Reply —Depends on kind and quality of grease used. Conditions vary.
5 Replies—None.
2 Replies—Little or none with proper grease.
3 Replies—Very little if properly filled.
3 Replies—Considerable in warm places and improper grease being used.
1 Reply —Considerable.
1 Reply —Leaks for about a week after greasing.
1 Reply —There should be no leakage with proper bearings.
1 Reply —2/3 grease lost without doing its intended work.
1 Reply —No grease leakage with bearing seal of more recent improved design.
1 Reply —Very little, unless motors are subject to excessive vibration and over-greasing.

Although some opinions are that considerable grease leakage exists on Anti-Friction bearings, the majority of opinions indicate very little grease loss under normal operating conditions.

Question No. 5—What type of grease has been found most suitable for Ball or Roller bearing lubrication?

1 Reply —Sun oil grade D.
3 Replies—Keystone Grade No. 3.
1 Reply —Pure petroleum grease.
1 Reply —A good soda soap base grease made out of a good grade of oil or cylinder stock, Viscosity slightly heavier than vaseline.
1 Reply —Fibre grease grade No. 5.
1 Reply —Calcium grease.
1 Reply —A good grade of cup grease.
1 Reply —Molilubricant and N. Y. & N. J. 000 grade non-fluid oil.
1 Reply —A No. 1 Acid free mineral grease.
1 Reply —"Lubuko."
1 Reply —Tulc lubricants.
1 Reply —A lime base lubricant free from acid, having 10% good fat, 300 Vicosity Mineral Oil, 100 seconds—Saybolt.
1 Reply —High heat test fire cooked grease.
1 Reply —Not too heavy, acid proof.
1 Reply —Depends on type of bearing and condition.
1 Reply —Standard oil and No. 3 Grease.
2 Replies—A light soft stringey grease.
1 Reply —Depends on speed, high speed light oil, moderate speed medium oil—Mobile "A".
1 Reply —Keystone and Vaseline.
1 Reply —Lancashire Motor roller bearing grease except for high temperatures where Prices Belmoline "C" high temp. grease is used.
1 Reply —We have not settled this question.
1 Reply —Soft grease with no residue.
1 Reply —Any neutral grease that does not run under heat too easily or become stiff in cold.
1 Reply —Any light grease consisting of Vaseline.
1 Reply —Texas Morfoch.
2 Replies—Pure oil base.
1 Reply —The grade recommended by any lubricating company for this service.
1 Reply —Light grease without filler.
1 Reply —Texaco No. 1 and Alemite grease.
1 Reply —Special ball bearing grease with straight mineral oil base compounded with lime and soda flow point not less than 150 degrees F., moisture and acid content less than 2%.
1 Reply —Murafat No. 3 Texas Grease Company.
1 Reply —H. T. Roller bearing grease Pennsylvania Lubricating Co.
1 Reply —First Keystone, petroleum jelly.
1 Reply —Houghtons F9.
1 Reply —A lubricant of vaseline consistency, free from residue, free from Alkali which draws moisture, free from acids, water repellant, good heavy oil to keep lubricating qualities under high speeds and temperature. Must not be made with grease containing soaps as these must be made from emulsions of materials with unstable base which will break down easily, especially under high temperature.
1 Reply —Depends on size and speed of bearing in general No. 2 or No. 3 consistency.
1 Reply —Grease with a large percentage of sodium-soap base gives the best results.
1 Reply —Medium consistency soda soap grease.

The replies to this question are contradictory and no two opinions are in accord on the subject. It is evident that satisfactory results are obtained in some places with one grade of grease and in other places with another grade. In general, acid base greases are to be avoided, inasmuch as they attack and pit the bearings.

Question No. 6—Should standard specifications be provided for grease so as to arrive at uniform conditions?

30 Replies—Yes.
1 Reply —No. Oil companies should make recommendations.
1 Reply —Can't be one satisfactory grease.
1 Reply —Can anybody write standard specs.?
1 Reply —Usually specified by manufacturer.
1 Reply —Of no value for single grease of possible value for a series.
1 Reply —Grade should be selected to suit conditions.
2 Replies—With our present results, no standard specifications were necessary.
1 Reply —This would be very difficult.
1 Reply —No.
1 Reply —Do not think so.
1 Reply —It is impossible to provide standard specifications.

The majority of replies to this question indicate that standard specifications for roller bearing grease

would materially improve the grease and results obtained therefrom.

Question No. 7—What methods are used to insure that only ball or roller bearing grease will be used in bearings?

12 Replies—Responsible man in charge.
1 Reply —There is no such thing as Ball or Roller bearing grease.
6 Replies—Instructions with units.
3 Replies—Special grease gun with fittings.
6 Replies—By keeping in separate marked container.
1 Reply —None should be necessary.
1 Reply —Check consumption—Strict rules.
1 Reply —Shop supervision.
2 Replies—None.
2 Replies—Schedule and supervision.
1 Reply —Usually bought that way.
1 Reply —Ordinarily little attention is paid the principle reason being that purchasing agents do not like to pay extra cost.
4 Replies—Gave no answer.

The nature of replies to this question indicates that ordinarily very little attention is given to see that correct grease is used in the bearings, however, it is reasonable to expect that to obtain satisfacory results, intelligent application of grease in quantity and quality is required and there are numerous schemes to accomplish this, some of which are mentioned above.

Question No. 8—How often should motor bearings be flushed and thoroughly cleansed of grease residue?

20 Replies—Once every year generally.
1 Reply —From two to four times per year.
8 Replies—Not necessary.
1 Reply —When armature needs rewinding.
4 Replies—Every six months.
1 Reply —Every time they come to shop.
1 Reply —Once a month.
3 Replies—Depends on service.
1 Reply —Once or twice yearly.
1 Reply —3 years for shop. Mill and Crane when motors are repaired.
1 Reply —6 months on Mill Motors—18 months on Crane Motors.

The majority of opinions on this question indicates that once a year is sufficient to cleanse bearing and repack with new lubricant.

Question No. 9—How often should bearings be disassembled for inspection of bearings and grease?

19 Replies—Generally each year.
1 Reply —Two to four times per year.
5 Replies—Depends on attention, type of service and size of bearing.
7 Replies—Not necessary.
1 Reply —Every 6 months.
1 Reply —Every month.
2 Replies—Every two years or when in for repairs.
1 Reply —Three months to one year.
1 Reply —Every two or three years.
1 Reply —Indication of Excessive Vibration.
3 Replies—No answer.

In general, once a year should be sufficient to disassemble, inspect and cleanse bearings and repack with new lubricant, as evidenced by the majority of replies to this question.

Question No. 10—What is the variation in temperature in which the motor operates throughout the year? Is it practical to draw specifications for a grease that would suit all conditions?

4 Replies—0 to 100 degrees Fahrenheit. Yes.
1 Reply —Check temperature and provide grease to suit conditions.
1 Reply —30 to 150 degrees F.—Same grease.
4 Replies—Yes.
1 Reply —20 to 110 degrees F.
1 Reply —20 to 130 degrees F.
1 Reply —40 to 90 degrees F.—Yes.
1 Reply —0 to 212 degrees F.—Yes.
6 Replies—No.
1 Reply —80 to 160 degrees F.—Yes.
1 Reply —20 to 125 degrees F.
2 Replies—Up to lubricant manufacturers.
1 Reply —40 to 110 degrees F.
1 Reply —(-10) to +100 degrees F.—Same grease.
1 Reply —(-15) to 110 degrees F.—Don't know of a grease.
1 Reply —Slightly heavier grade in summer.
1 Reply —10 to 150 degrees F.—Yes.
2 Replies—0 to 100 degrees F.—No.
1 Reply —(-5) to 100 degrees F.—Yes.
1 Reply —(-10) to 95 degrees F.
1 Reply —65 to 135 degrees F.—Yes.
1 Reply —0 to 150 degrees F.—Yes.
1 Reply —40 to 160 degrees F.—No.
1 Reply —0 to 50 degrees F.—Yes.
1 Reply —60 to 80 degrees F.—No.
1 Reply —(-15) to 200 degrees F.—No.
1 Reply —0 to 75 degrees F.—Yes.

In reply to this question, the general opinion seems to indicate that it is impracticable to draw specifications for one grease that will be satisfactory for operation through the wide range of operating temperatures.

Question No. 11—Is it advisable to place the greasing of motors under one head to obtain uniformity of practice?

37 Replies—Yes.
3 Replies—No.
1 Reply —Optional.
4 Replies—No answer.

In this case, it is considered advisable to place the responsibility for greasing motors under one head to obtain best results.

Question No. 12—What system of greasing motors do you favor, grease cup application or gun application?

33 Replies—Favored gun application.
6 Replies—Favored grease cups.
2 Replies—Neither, open housing, clean and repack.
1 Reply —Depends upon design.

Gun application with special fitting for motor bearings, to insure that only person responsible for motor bearings will grease same, is good practice.

Question No. 13—Do you consider it advisable to occasionally overgrease Roller Bearings in order to partially flush out worn grease and cleanse the labyrinths of foreign substances that may have collected?

25 Replies—No.
14 Replies—Yes.
2 Replies—Optional.
2 Replies—No answer.

In this instance, it is not advisable to cleanse housings by overgreasing. If cleansing is required, it is better to wash out bearing and repack with new lubricant.

Question No. 14—Is objectionable heating of bearings experienced on account of overgreasing?

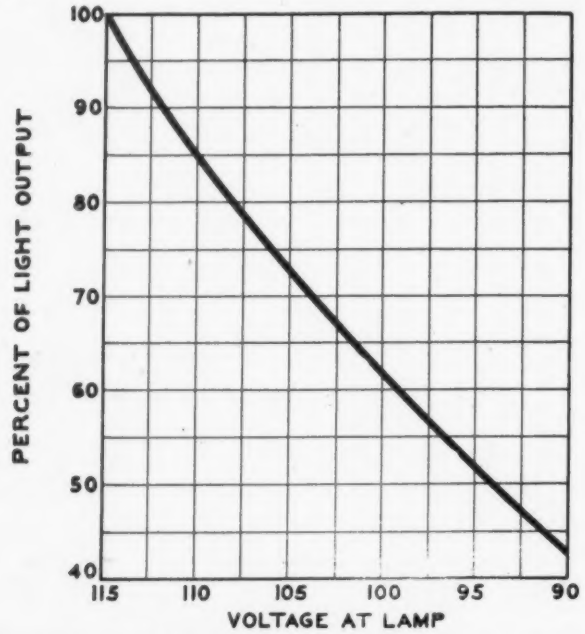
26 Replies—Yes.
11 Replies—No.
2 Replies—Doubtful.
1 Reply —Optional.
2 Replies—Not to our knowledge.

It is not advisable to overgrease Roller Bearings, inasmuch as bearings will heat up and excessive lubrication of these bearings is not required for good operation.

*Surveys of Lighting and Voltage in the Steel Industry**

By SAMUEL G. HIBBEN†

It has been affirmed that good lighting is an investment in plant equipment, returning substantial dividends in increased production. To this statement, the iron and steel industry must subscribe wholeheartedly as evidenced by the fact that during the past few months, there has been an extraordinary amount of attention given to studying mill lighting conditions and to laying the plans for the best feasible utilization of electric lighting power and apparatus.

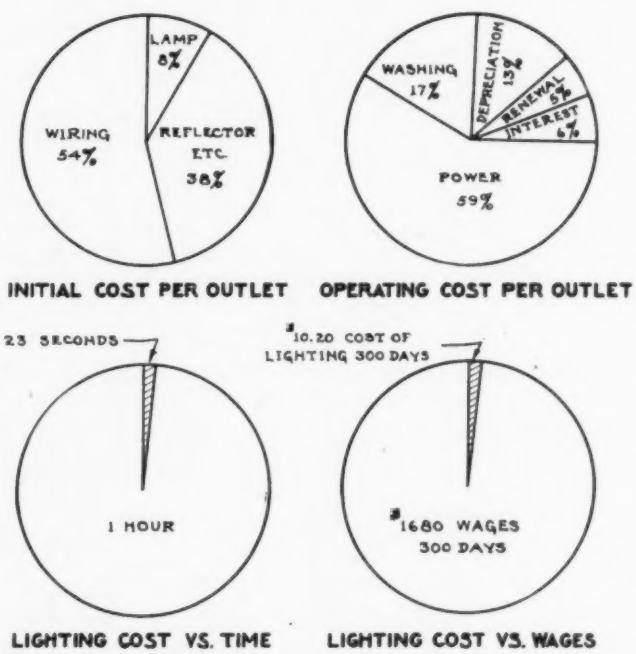


PERCENT OF LIGHT OUTPUT OF 115 VOLT LAMPS BURNED AT VARIOUS VOLTAGES

Standards of production and of material have considerably increased, and are still growing. Not only does the desire for increased volume of output call for the utilization of every feasible means for improving plant operations, but as well, the ever-present fact of competition imperatively demands every possible reduction in unit costs. Labor seeks safer and more cheerful surroundings, and employers are doing their utmost to provide such surroundings, knowing that in the last analysis, each workman is a high-priced machine to be protected against wear and tear, fatigue and obsolescence. Good lighting helps to increase output because it enables each workman to speed up his activities without strain and without friction. Thus good lighting is oil for human machinery and costs less in relation to the cost of man-power than does good oil in relation to inanimate machinery.

What are the steel companies doing in recognition of these facts? First, it is well understood that standards of lighting have changed in the last decade and that we must recognize higher levels of illumination just as we recognize and insist upon better ventilation, heating, transportation, and a host of other advances in civilization. It is proven that two or three footcandles of artificial lighting that was, in truth, all that could be had with the equipment available twenty years ago, has no economic basis for existence today. Furthermore, we can secure ten times these intensities at about the same costs as formerly. Under such higher intensities, we now know that men move faster and surer, that accidents and mistakes are avoided, and that as volume increases, unit costs go down. The operating engineers are awake to these facts, and mill lighting is growing better.

GOOD LIGHTING COSTS SO LITTLE



It is further recognized that good lighting in general costs very little if more than poor lighting, if we can eliminate unnecessary wastes in the distribution and utilization of electric power. In the past ten years, the efficiencies of Mazda lamps have about doubled and the costs have been more than cut in half. The art of manufacturing reflecting accessories has undergone similar changes. Nevertheless, to a large extent, there still remain unimproved the items of proper distribution of electric power for lighting and the proper maintenance of lighting equipment. Adequate wiring and scheduled cleaning have not kept pace with the progress in the other items of a modern lighting system.

To determine more fully the lighting conditions

*Presented before Twenty-fifth Convention, A. I. & S. E. E., June, 1929.

†Manager Commercial Engineering Department, The Westinghouse Lamp Company, New York, N. Y.

in the steel industry today and to form a basis for immediate and future improvements, there have been carried on during the past two years some very extensive surveys of lighting conditions in the iron and steel industry, some of the results of which are presented in the following paragraphs.

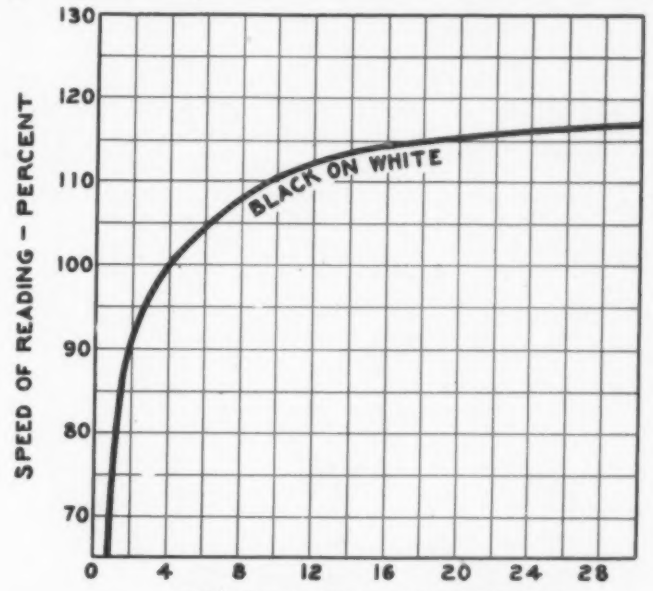
The most outstanding facts disclosed by a lighting survey of some of the largest steel mills in the country is that lighting loads have outgrown existing wiring capacities. In some cases, the old wiring was planned for 230 volt range lamps and when changed over to 115 volt lamps, brought about heavier current loading and corresponding increases in voltage drops. In other cases, higher wattage lamps have been substituted for those originally planned and in still other cases the relatively cheap cost of electric power and the high cost of copper has led to the use of insufficient feeder sizes with resultant low voltage at lamp sockets. As an instance of the conditions found in typical mills, note the following tabulation of some test results:

SUMMARY—GENERAL VOLTAGE CONDITIONS

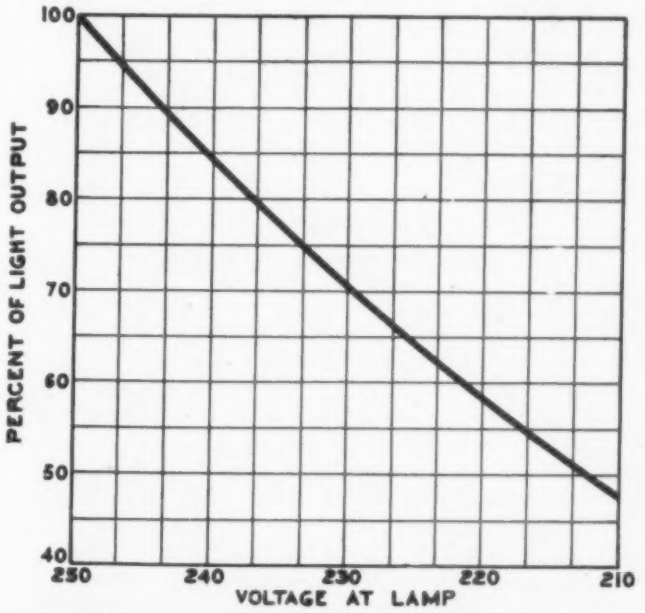
Location	Readings in Volts	Where Taken
No. 4 Mill Transformer	104	At socket near beginning
	98	At socket at middle
	85	At socket near end
Open Hearth Department	89	At switch lights off
No. 1 Transformer	80	At switch lights on
Laboratory Transformer	107	At socket near beginning
	105	At socket near end
Trestle Repair Shop	87	At socket
Blooming Mill Storage	79	At switch no lights
	68	At switch with lights
Blooming Mill	81	At switch with lights
Soaking Pits	74	At switch with lights
Stripping Building	106	At switch no lights
	104	At switch with lights
Open Hearth Water Treating	101	At socket
Open Hearth Side Lights	93	At switch no lights
Open Hearth Top Lights	94	At switch no lights
(No. 1 Transformer Circuit)	88	At switch with lights
Open Hearth	102	At switch with lights
No. 2 Transformer Circuit	100	At switch with lights
Foundry Dept. Transformer	98	At switch no lights
House	95	At switch with lights
No. 1 Foundry Department	107	At socket
Foundry Dept. Mach. Shop	97	At socket
Ladle Repair Shed	103	At switch no lights
	101	At switch with lights
Boiler Shop	90	At socket
D Cast House	98	At socket
Furnace Riggers Tool Rm	100	At socket
G Furnace	104	At socket
H and I Engine Room	90	At socket
Boiler House	105	At socket
Trestle Repair Shop	87	At socket
Blast Furnace Office	93	At socket
J and K Furnace Office	106	At socket
Car Dumper	95	At socket
Cent. P. H. at Transformer	114	At socket
J and K Stock Yards	85	At socket near feeder
	70	At socket at end of circuit
L C L Store Room	82	At switch lights off
	78	At switch lights on
Electric Store Room	84	At switch lights on
Electric Shop	93	At switch lights off
	86	At switch lights on
Roll Shop	90	At switch lights off
	85	At switch lights on
Mach. Shop Side Lights	100	At switch lights off
	90	At switch lights on
Machine Sh. Overhead Lts.	93	At switch lights off
	85	At switch lights on
Blacksmith Shop	95	At switch lights off
	90	At switch lights on
No. 1 Yard Finishing Mill	90	At switch lights off
	81	At switch lights on
Transportation Dept. Office	95	At socket
No. 2 Mill	95	At socket
Blooming Mill	75	At socket

From the aboye examples, it is at once evident that towards the ends of long runs, the voltage is some 10 to 30% lower than it is at sockets near the main distribution centers and that when throwing on load, there is at best a full load drop of 2 to 10 volts.

Let us discuss these facts from the standpoint of lighting economy. In the first place, a Mazda lamp



is in essence a delicate piece of machinery, designed to give its maximum light output at its designed voltage rating. Roughly, a 1% drop in voltage at the lamp causes a 3% decrease in candlepower or



PERCENT OF LIGHT OUTPUT OF 250 VOLT LAMPS BURNED AT VARIOUS VOLTAGES

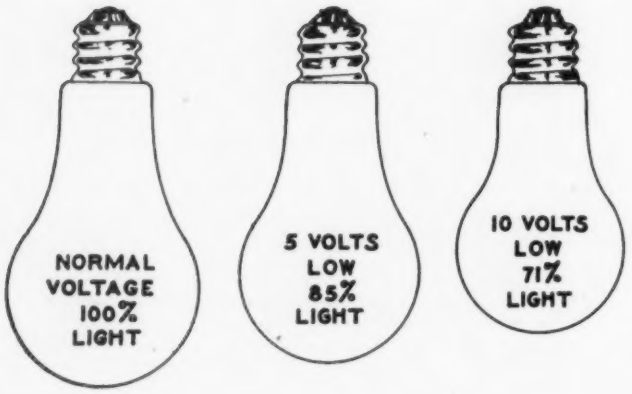
lumen output. Hence a lamp burned 5 or 6 volts under its rating can be expected to give only about 85% of its rated output. If, referring to the above table, a 110 volt rated lamp is burning in a socket

supplied with 90 volts, it is operating at 20 volts or 18% below rating and giving just about half of its proper candlepower.

In such cases, the line loss (I^2R) is an economic waste and a very inefficient form of heating. A simple calculation will show somewhat the following:

The IR drop in wiring = 20 volts
Assume 6 — 200 watt lamps on circuit, or rated load = 1200 watts
At 90 volts, the circuit current = 13.3 amps.
The resistance may be 20 divided by 13.3 or = 1.5 ohms
(This might be 1000 ft. of No. 12 wire, etc.)
The line loss would be I^2R, or = 265 watts
Consequently 22% of the lamps' power consumption is used in feeding them, and if the wiring were good, an extra 200 watt lamp might be burned on this circuit without any more metered power.

GOOD WIRING
AIDS
GOOD LIGHTING



VOLTAGE DROPS GREATLY
REDUCE LAMP EFFICIENCIES

Another important consideration is the one that should be given to voltage fluctuations. If a lamp of proper voltage rating is used on a circuit, say, at a point near the position of best voltage, it may be forced to burn at over-voltage during conditions of no load or light load on the system. At best, the voltage fluctuations incidental to a load change on overloaded branch circuits are bothersome to workers. During darker hours of the day and at night time, when artificial lighting should be at its best, it is, because of heavy loads, naturally at its worst.

The fallacy of securing a long burning life from a lamp when operated below its voltage rating, lies in the fact that with the increase in the temperature of the filament, the light output goes up faster than the watts input. Thus to get increased lamp life by cutting the wattage input 10% causes the lumen output to be reduced 25%. And after all, the cost of the lamp bulbs is only some 5% to 6% of the total cost of operating a lighting system, so the sensible economies lie in the direction of reducing power costs, not in reducing lamp bulb renewals at the expense of power. In general, the cheapest lighting can be obtained when lamps are burned at rating. With every reduction in the cost of the lamp bulb itself, this becomes increasingly true.

Frequently, from the surveys mentioned above, it became evident that a slight increased investment in copper and a consequent rise in the socket voltage would enable the use of the next smaller size of lamp bulb without any decrease in the working plane illumination. Nor is it feasible to correct low voltage conditions by attempting to purchase lamps designed at say, 100 or 95 volts rating. Such lamps are of small demand and hence of special production and their costs are consequently greater than for the standard 110, 115 or 120 volt lamps.

It has not been considered practical in the same mill to stock two different voltages of lamps, for reasons well understood by maintenance men. The ideal condition would be to design wiring circuits so that not over a 3% difference in voltage would occur as between the best and the worst position of socket, and while this condition is not practical in most mills having long feeder and branch circuit runs, yet certainly the existing conditions need improvement and certainly when making improvements (largely by tapping in some extra distribution feeders at strategic points), provisions should be made for the inevitable future growth in lighting standards and future demands made in wiring circuits.

It is true that lamp efficiencies have increased remarkably in the last few years but from all that is known today, there is a limit to the safe temperature at which a tungsten filament can be operated and the largest efficiency hoped for in the near future will have to result from better voltage regulations, saner choice of lamp sizes, and more efficient lamp accessories.

As regards a sane lamp size, let it be understood that the higher the lamp wattage, the more lumens per watt are obtainable from it. Where one large lamp can be substituted for several smaller ones, there is a consequent rise in lighting efficiency and the only limit in this practice is the question of uniform distribution and the avoidance of glare. The surveys disclosed a general trend in this direction.

Another fact that the lighting surveys bring to light is the one of cleaning and maintenance. The prevalent dirty condition of reflectors in steel mills is not generally due to unusual neglect but due to inaccessibility of lighting units coupled with the unusually dusty conditions of the atmosphere. Engineers making surveys have endeavored to leave with the maintenance men the following condensed cleaning suggestions:

1—Water is cheaper than watts. Cleaning pays. There is no substitute for it.
2—Before the unavoidable accumulation of dust and dirt is usually noticeable, the lighting efficiency is materially reduced. After four weeks of inattention, the reduction is on the order of 20%. Even with clean surroundings, a loss from dust and smoke of from 10% to 15% may be reasonably expected in a single month.

3—Establish a regular systematic maintenance schedule and do not wait to replace a burned out lamp before cleaning the reflector. Wipe off units at least once monthly and wash the equipment every two to three months.

4—When cleaning, remove the lamp bulb, if possible, and wipe off the reflector, avoiding greasy rags or waste. About one half cup of commercial ammonia to a pail of water will cut the grease. Lamp bulbs should never be completely immersed in water. If washing with soapy water, thoroughly remove the soap films which otherwise readily collect a fresh coat of dust.

5—It is a good plan to number each reflector and mark thereon the proper lamp size. This facilitates re-lamping and helps to avoid the all too prevalent custom of putting in a larger bulb than the reflector is designed for.

6—The hard mixture of iron dust and grease baking on reflecting surfaces can be removed with dilute oxalic acid.

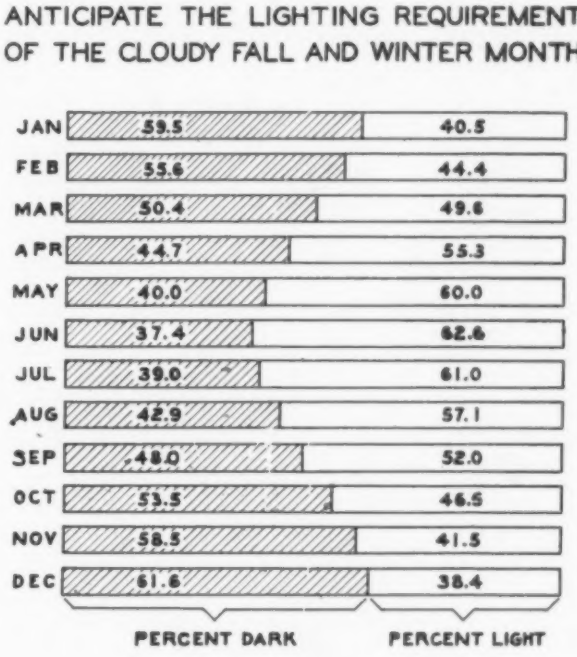
7—If bulbs look black, remove them even though they may not have completely burned out. Some old timers may live far beyond the limits of their useful life and like very old men, are not efficient. They should be pensioned in the waste basket.

In quite a large number of steel mill installations, particularly those extending over large areas, the survey discloses the 250 volt lighting system as still quite common practice. While the cost of copper can undoubtedly be reduced by such high voltage systems, it is nevertheless a doubtful economy when taking into account the danger hazard as well as the higher cost and lower efficiency of the 250 volt Mazda lamp. It might be well to repeat the facts that the lamping bill can be expected to be about 25% greater when using high voltage lighting, as compared to the low voltage or 115 volt range lighting. The high voltage lamps are more expensive initially, they are from 15 to 20% less efficient in light output and with greater filament resistance, are necessarily more fragile. Taking all factors into account except wiring investment and transmission losses, the high voltage lighting usually cost between 50 and 60% more per generated lumen of light. Very seldom if ever does the saving in copper balance this loss.

Anyone familiar with steel mill distribution systems is acquainted with at least one effort that has been made to use low voltage lamps on high voltage systems. Reference is had to the practice of burning two 125 volt lamps in series across 250 volt lines. This practice seems to give fairly good results but slightly less than normal life is to be expected from such lamps. Although two new lamps usually operate satisfactorily in series, they do not grow old exactly in step. One lamp naturally fails sooner than the other. The filament of the remaining burnable lamp may be quite fragile and may suffer mechanical breakage in the investigation to determine which of the two lamps has burned out. Furthermore, the remaining lamp has a thinner filament and hence a higher resistance and if a brand new lamp is inserted in series with the old lamp, the changes are that the new lamp will have a slightly lesser resistance and hence the current through the old lamp will be a little greater than before. This causes the old lamp to fail a little quicker. One of the best practices is to always renew with two new lamps when one fails.

Since the subject of lighting has been formally discussed before this Association, there have been a number of improvements in the efficiency and durability of the reflectors and projectors. Surveys find these newer devices replacing the old (and usually badly corroded) equipment. One of the most outstanding developments is the chromium plated reflector especially suitable for high-bay mounting above cranes where a narrow beam is needed, where maintenance is liable to be infrequent, and difficult, and where the possibility of breakage constitutes a severe haazrd. The chromium reflecting surface is proof against tarnishing and enables the reflector to be light in weight and very easily cleaned by merely wiping off the dust.

The development of sealed floodlight projectors is also of interest to operating engineers because particularly in such locations as around blast furnaces,



soaking pits, open hearth charging floors and storage yards, it is difficult to provide a plurality of overhead lighting units as well as to maintain them. The floodlight projector, especially with a spread or diffusing lens, if located at an accessible position, will illuminate a large area and at a long range. It may be satisfactorily cleaned by merely wiping off the front cover.

These few brief comments rather inadequately attempt to cover some of the outstanding findings of the illuminating engineers studying steel mill lighting. It may be said, however, that the results of the latest surveys find the company executives very much in sympathy with lighting improvements that effect increasing production and more safety to employees. Business conditions and the demands made upon the industry indicate that this summer and fall will witness some very considerable improvements in mill lighting for which the guiding recommendations are as follows:

1—Improve wiring conditions with extra feeder taps, the reduction of overloads on far-flung branch circuits, and with extra distribution panels at strategic load centers

2—Make a survey of socket voltages and a choice of voltage ratings of lamps to reduce the spread or gap between these two.

3—Divorce lighting circuits from power circuits.

4—Standardize on 115 volt range systems in the majority of buildings and eliminate 250 volt range lamps wherever possible.

5—Establish systematic cleaning systems making lamp renewals and reflector cleaning as definitely a part of plant operations as the oiling of machines.

6—Eliminate small, shallow, rusted and outgrown, inefficient reflectors in favor of the adequate and newer units.

7—Employ sealed units or floodlight projectors for dusty areas and long throws.

As lighting surveys in the steel industry progress, and as resultant improvements take place, it is safe to say that in no other industry as a class will improvements be so beneficial to safety, to production, and to consequent wages and dividends.

CORRECTION

ELECTRIC WELDING COMMITTEE REPORT

June Issue, 1929

In the "Report of Electric Welding Committee" in June issue of the Iron and Steel Engineer, page 390, second paragraph, beginning in line twelve, should read: "The time required to make a weld with a properly proportioned equipment, using about 2500 to 3000 amperes, per square inch-**second**, will vary from less than one sec. to 15 sec. where a current density of not less than 250 amp. per sq. in. is used." The substitution of the word "section" makes a contradictory statement of no value.

As stated, we have a rough rule for amps. required for welding, that is if the section is 5 sq. inches and the time allowance 10 secs., we have

$$\frac{2500 \times 5}{10} = 1250 \text{ amp. minimum}$$

$$\frac{3000 \times 5}{10} = 1500 \text{ amp. maximum}$$

as the probable limits of current to be provided in conductors and contacts.

The following is the result of the ballotting for the election of officers for the ensuing year:

DIRECTORS 1929-1930

F. W. Cramer, President—Chief Electrical Engineer, Republic Iron and Steel Company, Youngstown, Ohio.

R. M. Hussey, 1st Vice Pres.—Electrical Supt., Jones & Laughlin Steel Corp., Aliquippa, Pa.

F. O. Schnure, 2nd Vice Pres.,—Electrical Supt., Bethlehem Steel Co., Sparrows Point, Md.

James Farrington, Treasurer—Electrical Supt., Wheeling Steel Corp., Steubenville, Ohio.

W. E. Miller, Secretary—Electrical Supt., Bethlehem Steel Company, Bethlehem, Pa.

S. S. Wales, Director at Large—Chief Electrical Engineer, Carnegie Steel Company, Pittsburgh, Pa.

L. C. Edgar—Chief Engineer, Carnegie Steel Company, Edgar Thomson Works, Braddock, Pa.

Walter Greenwood, Engineering Section Director—Safety Engineer, Carnegie Steel Company, Youngstown, Ohio.

F. E. Leahy, Engineering Section Director—Fuel Engineer, Youngstown Sheet & Tube Company, Youngstown, Ohio.

G. A. Lamberton, Director—Assistant Electrical Engineer, National Tube Co., Lorain, Ohio.

Geo. Pfeffer, Director—Electrical Supt., Florence Pipe Foundry & Machine Company, Florence, New Jersey.

J. J. Booth, Director—Asst. Electric Supt., Gary Tube Company, Gary, Ind.

E. P. Winters, Director—Steam Engineer, Sloss Sheffield Iron and Steel Co., Birmingham, Alabama.

JOHN F. KELLY, Managing Director—Association of Iron & Steel Electrical Engineers, Pittsburgh, Pa.

Symposium

Blast Furnace Gas Cleaning

Presented before the Combustion Engineering Division of the Association of Iron and Steel Electrical Engineers at their Mid-Winter Conference held in Duquesne, Pa., January 24, 1929.

Mr. S. G. Worton, General Superintendent of the Duquesne Works of the Carnegie Steel Company, acted as Chairman of this Conference, and Mr. F. E. Leahy, Fuel Engineer of the Youngstown Sheet and Tube Company at Youngstown, Ohio, was the Secretary.

Blast Furnace Gas Cleaning—

By W. J. McGurty, Bartlett Hayward Company, Baltimore, Md.

Blast Furnace Gas Cleaning—

By C. W. Hedberg, Research Corporation, Bound Brook, N. J.

Discussion

MR. H. C. SIEBERT, Combustion Engineer, Bethlehem Steel Co., Bethlehem, Pa.
MR. GORDON FOX, Electrical Engineer, Freyn Engineering Co., Chicago, Ill.
MR. J. C. HAYES, Mechanical Engineer, Freyn Engineering Co., Chicago, Ill.
MR. F. E. LEAHY, Fuel Engineer, Youngstown Sheet & Tube Company, Youngstown, O.
MR. S. G. WORTON, General Superintendent, Duquesne Works, Carnegie Steel Co., Duquesne, Pa.
MR. R. S. COULTER, Combustion Engineer, Bethlehem Steel Co., Sparrows Point, Md.
MR. L. E. RIDDLE, Superintendent of Blast Furnaces, Carnegie Steel Co., Duquesne, Pa.
MR. T. A. LEWIS, Combustion Engineer, Bethlehem Steel Co., Bethlehem, Pa.
MR. L. J. REED, Assistant Chief Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.
MR. WALTER DE FRIES, Chief Engineer, William B. Pollock Co., Youngstown, O.
MR. A. C. CUMMINS, Electrical Superintendent, Carnegie Steel Co., Duquesne, Pa.
MR. R. M. HUSSEY, Electrical Superintendent, Jones & Laughlin Steel Corp., Aliquippa, Pa.
MR. I. A. NICHOLAS, Special Engineer, Carnegie Steel Co., Clairton, Pa.
MR. J. E. DUNN, Fuel Engineer, Republic Iron and Steel Company, Youngstown, Ohio.
MR. W. B. CHAPMAN, Director, Chapman Stein Company, Mt. Vernon, Ohio.

Blast Furnace Gas Cleaning

By W. J. McGURTY

The past five years have witnessed a stimulated endeavor to secure for all plant purposes blast-furnace gas of as high a degree of cleanliness as can be economically obtained.

This stimulus has been provided by the evolution and application of an effective mechanical scrubber to this service, and in reviewing the art of gas cleaning it is evident that whenever gas of high quality has been desired, it has been absolutely necessary to employ wet treatment to effect this result.

With the gradually increasing scope of utilization of its gas, the blast furnace is practically a unit in a cyclic process; consequently its operation has some bearing on the operation of all auxiliary and other equipment to which the gas is supplied.

The caloric value and constitution of blast furnace gas, together with the volume produced, will naturally vary with the amount of carbon-bearing materials in the burden, and various investigations have shown that the gas will contain from 45 to 68 per cent. of the calorific value of the coke used, the higher figure referring to ferro-manganese operation.

Solids Content

The exiting gases carry a representative of every element that entered with the burden, as well as other products formed by thermo-chemical reaction in the various zones of the furnace.

Classifying them in the order in which they are eliminated, we have

I. TRUE DUST, consisting of particles of ore, stone, coke, etc.

II. FUME, or sublimates of metallic and non-metallic constituents, and

III. VAPORS of the above constituents which must be cooled before their transition to the solid phase.

I would state here, however, that the difficulty of their elimination is the reverse ratio to the above.

A brief discussion of the three groups may aid in a better understanding of the problems attending the cleansing of the gas.

I. TRUE DUST.

Usually termed "flue dust," its amount per cubic foot of gas is largely dependent on the following physical factors:

(a) Character of the raw materials charged with particular respect to their degree of fineness, as shown by sieve tests.

(b) Distribution and movement of the stock.

(c) Gas velocities in the furnace, particularly at the stock line.

Due to variables in the above factors, furnaces in the same plant, operating on the same burden, will emit varying amounts of dust particles with the gas.

The removal of the heavier dust particles is partly effected by gravity settlement in the primary dust catcher, but the amount is naturally limited by the relative fineness of the particles. The following tabulation of screen tests made at several scrubber installations illustrates this fact:

Through Number	FURNACE "A" Dust Catcher	FURNACE "A" Entering Scrubber	FURNACE "B" Dust Catcher	FURNACE "B" Entering Scrubber	FURNACE "C" Dust Catcher	FURNACE "C" Entering Scrubber
325	1.6%	11.6%	4.5%	99.55%	13.9%	86.5%
270	2.8	17.0	6.8	99.80	33.8	94.9
200	4.4	18.8	12.2	99.85	36.3	96.1
100	9.6	50.2	39.5	99.90	47.8	98.9
80	15.0	65.4	51.8	100.00	54.6	99.4
60	25.2	81.0	78.3	----	64.4	99.7
50	46.4	92.0	94.5	----	75.3	99.8
40	56.6	95.0	98.5	----	79.6	99.9
30	80.8	97.8	99.5	----	88.6	100.0
20	95.4	99.0	99.8	----	95.5	---
10	99.0	100.0	100.0	----	98.5	---

(Note—"A" and "B" in same plant with similar burden)

Mr. E. Kieft[1] has made some very interesting calculations on the gas velocities necessary to move dust particles of various sizes, indicating that the following gas velocities in feet per second will lift the particles passing through the respective screens:

7.0 feet for 100 mesh
7.7 feet for 80 mesh
8.8 feet for 60 mesh

With fine ore burdens, such as Mesaba, the average dust content after the primary dust catcher will range from 6.0 to 8.0 grains per cubic foot of gas, which may be increased to from five to ten times this quantity during furnace "rolls" or "slips." At such times the gas will pick up some of the dust that has previously been deposited in the primary catcher during period of normal gas conditions.

It is the fundamental duty of the gas cleaning equipment to not only salvage this material, but to prevent it also from entering the gas distributing mains.

II. FUME, known to the non-ferrous metallurgist as "metallurgical smoke" —a very descriptive term,—consists of the sublimated or condensed particles of the vapors formed by thermo-chemical interaction in the furnace. Condensation from vapor to solid phase occurs in the upper part of the stack with the amount naturally depending on the top gas temperature, and the type of vapor produced.

These particles are very minute in size, have a high surface tension, and their comparative density with that of the gas precludes any possibility of removing them without recourse to a very vigorous treatment.

[1]Iron and Steel Engineer, July, 1927.

III. VAPORS, consisting of the uncondensed metallic and other vapors, that will require further temperature reduction before any change in condition is possible.

The formation and characteristics of the above products are dependent primarily on the alkalies present in the burden, then on temperature. It is evident that in all furnace operations there is some production of "fume," but the lower top temperatures tend to retain them in the stock, and it is only under extreme conditions that they appear in the distributing mains, and at such periods their presence is very noticeable.

It is axiomatic that in high temperature operations such as ferro-manganese and with special irons, the higher temperature of the exiting gases means that increased quantities of these constituents will be present also that the proportionate amount of "vapor" to "fume" will be higher in the gas leaving the furnace.

In a survey made by the Bureau of Soils to determine the Potash resources possible in the iron industry the following tabulation[2] shows the relative amount in various ores:

POTASH IN DOMESTIC AND FOREIGN ORES

Source	Ores Analyzed	Samples Analyzed	Potash (K20)
Mesaba Range	76	126	0.09%
Gogebic Range	26	46	0.10
Menominee Range	26	36	0.28
Marquette Range	22	31	0.23
Cayuna Range	8	8	0.10
Vermillion Range	4	9	0.11
Alabama	6	8	0.55
New York	3	3	0.10
Virginia	4	4	0.32
New Mexico	5	5	0.10
Georgia	3	3	0.82
Miscellaneous Domestic	10	11	0.51
Foreign Non-Manganif.	5	6	0.14
Foreign Manganiferous	11	22	0.77

Weighted Average for all Ores 0.19%

This represents but a portion of the alkalies entering the furnace, and taking the potash as an index, from 70 to 80 per cent. of the alkali "fume" products leave the top of the furnace, and for the most part they are water soluble products, with their solubility increasing with the temperature of the water.

"Fume" particles, in addition to their extreme fineness and density, have also the factor of absorbing gases which would aid in increasing their buoyancy in the gas stream.

Cleansing

After due consideration of the problems involved, it is evident that wet scrubbing affords the most adequate means of treating a material of the complexity of character of blast furnace gas.

The instrument employed, however, must be designed to take advantage of the physical factors necessary for the elimination of the various objectionable constituents specified, and this was our fundamental and whole thought since reaching this conclusion.

[2]Journal Ind. & Eng. Chem., April, 1922.

Figure I. illustrates our primary scrubber unit, its operating results demonstrating that we have successfully embodied the features necessary to secure the advantages referred to above.

A mechanically produced spray is a continuous one, but to be effective its density and intensity should be capable of regulation, in order to provide the degree of penetration required to search out the

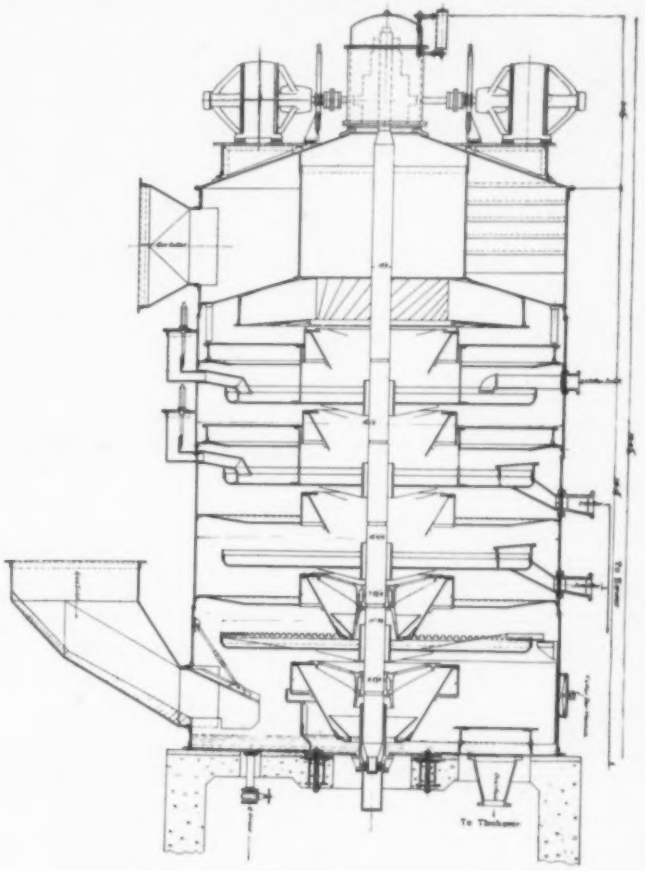


FIG. 1.

elusive solid particle, and this is the great variable in the cleaning job.

Since the specific viscosity of water is reduced as the temperature is increased, it follows that the same unit volume is distributed in much greater subdivision with consequent greater penetration at high temperatures than low. This same factor also accounts for the increased removal of the water soluble "fume" products present.

In its first contact, therefore, a very thorough removal of the "true dust" content, a large part of the "fume" and condensation of the "vapor" is effected.

The succeeding contacts rupture the gas envelope surrounding the "fume" particle and by wetting it provide a nucleus for attracting other particles of this character.

Necessity for Cleaning

The immense thermal resources available in blast furnace gas is leading it into a gradually widening field of utilization, with combustion as the basis for effecting this recovery.

In addition to the usual immediate furnace auxiliaries such as stoves and boilers, it is being enriched to varying degrees and found to be ideal for coke

oven heating and general steel mill purposes. The degree of cleanliness naturally depends on its utilization, but the stoves and boilers will account for the greater proportion of the total production.

Since the flame temperature of any gas is affected by the presence of inerts, such as solids and water vapor, it follows that any reduction of either constituent, is a corollary to increased combustion efficiency. This is not a theory but a clearly demonstrated fact.

The same half decade that has crystallized effort on the proper cleansing of blast furnace gas has witnessed a wonderful modernization program in the iron and steel industry. In view of this and knowing the effort and cost in collecting the raw materials needed for iron production, it seems like an economic crime to waste the metal values present in the raw gas, regardless of any consideration of its comparative efficiency as compared to properly cleaned gas

A furnace producing 600 tons of iron per day, from fine ores, with 133,000 cu. ft. of gas per ton containing an average of 8 grains per cu. ft. leaving the dust catcher, delivers 40 gross tons of dust per day to the distributing mains. At a comparative value of $3.00 per ton, the recovery of this material on a 350-day basis would amount to $42,000 per year, which, in itself, would provide a substantial credit to the furnace operation.

Greater concentration of the hotter wash water is an aid to the more effective recovery of its dust content, and the modern filter-type sludge concentrator corrects the losses and other difficulties inherent in the older types of cleaning and recovery systems.

If, according to metallurgists, the blast furnace is a better gas producer than a smelter, the most effective method to bring up its overall efficiency is the proper treatment of its gas product, thereby matching the effort expended in making its mechanical operation more satisfactory.

Blast Furnace Gas Cleaning

By C. W. HEDBERG

In any program which is adopted for improvements in the use and distribution of blast furnace gas, prominence must be given to the selection of equipment for removing the dust and fume suspended in the gas when it enters the furnace downcomers. A review of the situation would undoubtedly reveal that very definite economies have been effected in this direction in the past, largely as a result of improved cleaning equipment which has made available cleaner gas. At present the trend seems to be toward even cleaner gas for stoves and boilers, and new uses are contemplated which are predicated largely on the gas being available with barely a trace of residual suspended matter. These will be made possible to the extent that improvements and operating economies can be effected in cleaning systems and equipment.

The occasion of the present paper is to indicate what the industry can expect from Cottrell electrical precipitation.

Present Cleaning Systems

Existing practice is to divide the cleaning operation into three steps, as follows:

1. Preliminary cleaning for removing the coarser dust.
2. Primary cleaning. In this step the dust content is reduced to limits which at present range from slightly less than .1 up to .5 grains per cu. ft. at standard. Primary cleaned gas is used directly in stoves and boilers.
3. Secondary cleaning. This step cools the gas if this has not been done in the primary step, and further reduces dust contents to .015 grains, or less. Normally, only that portion of the gas which is to be used for engines receives secondary cleaning.

For each step there are several types of equipment. The arrangement and operation of the more common types are so well known that they do not require further description here.

Cottrell Electrical Precipitation

Cleaners built on this principle are of the so-called static type and are applicable for either primary or secondary treatment. When used as primaries they are of the type generally referred to as Dry Cleaners, the suspended material being recovered in a dry state. When they function as secondary cleaners the residual suspended material is recovered as a very thin slurry because of the entrained moisture from the cooling operation directly preceding them.

Precipitation first began to attract attention in this country about the same time that Forbes† and Diehl‡ published papers on blast furnace gas cleaning. These papers definitely directed attention to dry hot versus cold wet primary cleaning, and undoubtedly influenced the precipitation engineers of that period in selecting the dry hot primary cleaning as the proper field for precipitation. Until recently this has continued to receive maximum attention from American engineers. In Europe, on the other hand, there has been a more general recognition of the ability of precipitation to deliver gas of high cleanliness, and accordingly their efforts have been

†Forbes, "The Cleaning of Blast Furnace Gas," A. I. M. E., 1913.

‡Diehl, "Data Pertaining to the Gas Cleaning at the Duquesne Blast Furnaces," A. I. M. E., 1914.

directed largely to making it a system for fine cleaning all the gas.

Theory

The application of precipitation has proven somewhat more complex than statements of the simple underlying principle would indicate. The latter is probably familiar to most of you but it may be well to repeat it in order to bring out the complexities which have not had any extensive discussion.

Electrical precipitation of suspended dust and fume particles from a gas depends upon the generation in the gas of free electrical charges which accumulate on the suspended particles. Simultaneously, the gases are made to pass through zones across which there is maintained a high difference of electrical potential with the result that the charged particles are driven by electrostatic repulsion to the point of lowest field intensity.

In practice there are provided a number of gas passages, contained within a shell, which consist of either pipes or ducts which form the collecting electrodes and which are electrically connected to ground. Centrally in these gas passages, and electrically insulated from them are hung discharge electrodes, consisting of one or more wires, which are connected to the negative side of a source of high voltage unidirectional current. These wires are sufficiently small to permit stressing the gas, immediately adjacent the wire, beyond its electrical limit, to form a corona discharge when high potential differences are applied between electrodes. The free electrical charges thus generated attach themselves to suspended particles which are carried at a speed depending on amount of charge and field strength or applied voltage, into the uniform and weaker field at the collecting electrode where they lodge and give up their charge.

The complexities referred to above have their origin in a non-uniform electric field at the collecting electrode. Physical characteristics of this phenomenon are luminous patches on the collecting electrodes indicating localized fields of high intensity where it should be weak and uniform. Corona on the discharge electrode disappears excepting opposite to these luminous patches. There is such a disproportionately great increase in current flow across the intervening gap that the current saturation point is reached at a voltage below that required for effective precipitation. The mechanism of this phenomenon, which precipitation engineers term "back ionization," has never been satisfactorily explained, but it is known that the immediate cause is simultaneous precipitation on the collecting electrode of iron ore dust which, at the temperature of the gas, is electrically non-conducting and finely divided coke particles which are conducting, it having been duplicated in a laboratory dark room with synthetic mixtures of these materials.

Its effect on precipitation efficiency may better be understood by assuming an intact filter bag such as is commonly used in bag houses and which is essentially the same thing from a gas cleaning standpoint as a normally functioning electrode unit. If we shoot a number of holes into this bag we still obtain filtration through the intact portion, but a disproportionally large amount of raw gas escapes through the holes. This is the equivalent of the back ionization condition. If we pass this partially filtered gas through a series of bag filters, each of which have similar holes, it is conceivable that ultimately a completely cleaned gas can be obtained. This is equivalent to adding electrode sections in series, but it is apparent that it will be a relatively ineffective arrangement when compared to the normal electrode unit.

Another but less serious complication is due to the physical characteristics of the dust, particularly the lack of cohesion between particles at treatment temperatures. This results in an abnormal tendency for resuspension or carrying along of precipitated dust.

Electrical Precipitation for Primary Cleaning

In order to clean blast furnace gas which has had preliminary treatment in the dust catchers, to a dust content of 0.1 grains or less per cu. ft. at standard, consistently, it is necessary to condition such gas prior to treatment. This condition eliminates or reduces the bad effects of the side reactions discussed above, and may be accomplished by either of two methods. The first consists of adding hydrocarbon vapors to the gases, for example, by volatilization from coal added to the burden. Normally the equivalent of 25 to 30 lbs. of coal per ton of iron added in batches of 500 to 600 lbs. will produce the required effects and nothing has been found to indicate that it need exceed 40 lbs.

The other method involves cooling the gases to a point where the precipitated dust will absorb sufficient moisture to become uniformly conducting. Critical temperatures and corresponding moisture contents for improved operation are very approximately 200° F., 225° F., and 25 grains H_2O per cu. ft. dry gas at 62° F. and 30″ Hg.

The simplest equipment for this method of conditioning is a spray chamber in which the cooling is effected by means of the evaporation of a water spray. The following data calculated for a 600 ton furnace will serve to illustrate the operation:

Gas Vol. 69,500 c. f. m. dry gas at standard.

Analysis:		
	CO_2	13%
	CO	25%
	H_2	3%
	N_2	59%
	H_2O	25 Grs./cu. ft. dry gas at Std.

The gas is available at an average temperature of 400° F. and is conditioned by spray cooling to 200° F.-225° F. at the precipitator inlet.

This cooling converts 251,000 B. T. U. per minute from sensible to latent heat. 27.1 gallons of water will be evaporated and allowing for excess water which appears as drip in the spray chamber, approximately 50 gallons of water are required per minute. This added amount of water is equivalent to 24.5 grains, which added to the original 25 grains gives a final moisture content of 49.5 grains per cu. ft. of dry gas at 62°-30″. This corresponds to a dew point of 122° F. or approximately 95° lower than the dry bulb temperature of the gas after treatment.

If we further assume that the cleaned gas reaches the stoves or boilers at 200° F. and that the combustion gases leave these at 600° F., the added water

vapor will carry out an additional 42,000 B. T. U., so that that the total net heat loss by spray cooling amounts to 251,000 + 42,000 = 293,000 B. T. U. per minute. Normally there would be some cooling by radiation if the gas were not conditioned between the point of treatment and point of use so that this figure probably represents a maximum loss.

There is, however, a theoretical saving over wet scrubbing. This is equivalent to the difference between sensible heat in conditioned gas at 200° F. at point of use and the sensible heat in the wet washed gas minus the heat carried out of the stove and boiler stacks by the added moisture. If we assume washed gas saturated at 70° F. which is not an unusual condition, and stove and boiler waste gases at 600° F., there is for the assumed conditions a net balance in favor of the spray conditioned gas of 63,710 B. T. U. per minute. If wet washed gas contains appreciable entrained water, the balance is still higher.

From a chart which has been prepared to cover spray cooling of raw gas, the balance does not show in favor of a wet scrubber system until initial raw conditions are an average temperature of 500° F. and a moisture content of 50 grains per cu. ft. of dry gas at standard, so that from a sensible heat conservation standpoint we are no worse off when we spray cool and precipitate than we are with wet scrubbers.

The beneficial effect of conditioning on precipitator operation is illustrated by the following data from test on pilot units:

Precipitator	A	A	B	B
Duration of Tests—Days	11	27	2	2
Volume C. F. M. Average	10,650	10,845	1,250	1,260
Temp. °F. in Precipitator	358	366	250	187
Clean Gas—Grs./Cu. Ft. @ 62° F.-30" Hg.	.066	.292	.161	.017
% Dust Removal	96.2	88	93.2	99.0
Kilovolts-High Tension	53.5	49.3	49.8	60.1
Amperes-Low Tension	25.2	42	7.1	4.0
Conditioning	Coal Tar	None	None	Water Spray

Before proceeding with a description of typical installations for primary cleaning it may be well to define an installation as consisting of a battery of two or more separate precipitator units, or simply "units" arranged in parallel between the dirty and clean gas mains. A unit in turn consists of one or more sections of electrodes arranged in series in the direction of gas flow, usually in a single shell. Sections are electrically separate and may be separately energized or connected in parallel on one electrical set. The latter consists of a step-up transformer, a mechanical rectifier direct connected to a synchronous motor and the necessary control equipment and high tension line.

Colorado Fuel & Iron Company, Pueblo, Colo.

This installation operates on raw unconditioned gas. Present installed capacity is 360,000 c. f. m. at main conditions, or the total gas from three furnaces. It consists of 16 pipe type and 8 plate type units, all in parallel, each with a rated capacity, respectively, of 10,000 and 25,000 c. f. m. at main conditions. The former are similar to those originally installed at Dunbar and Sheridan, Pa., and described by Gellert & Laird, "Electrical Cleaning of Gases as Applied to Blast Furnaces," A. I. S. E. E., November 1919.

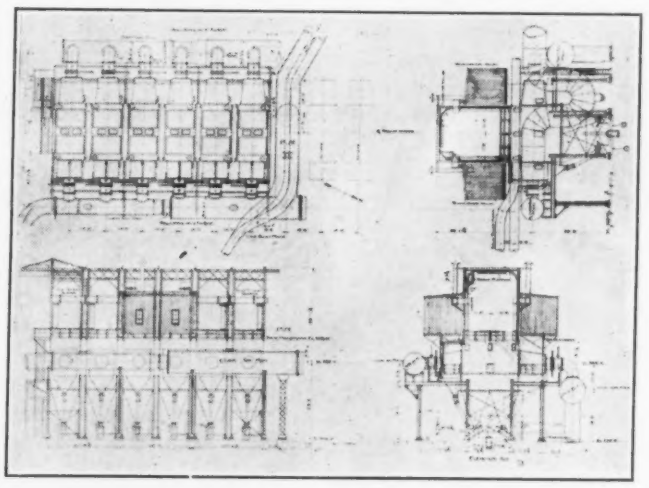
The latter are of the two pass type. The gases enter near the top and flow downward through the first section and then upward through the second, and leave near the top. The first section consists of six ducts formed by steel plate collecting electrodes 12′ high and 8′ wide, spaced 7″ apart, while the second section contains nine such ducts. The discharge electrodes are horizontal wires carried by vertical supporting chains suspended from insulated top supporting frames.

The installation is energized by 16 electrical sets, all contained in a single sub-station, and is reported to consume 180 to 200 K. W. H. which, at rated volume, is equivalent, approximately, to 1 K. W. H. per 100,000 cu. ft. at standard. Precipitated dust on both discharge and collecting electrodes is removed by an automatic rapping system which cuts off and raps each unit one at a time, once every 35 minutes.

The normal average temperature in the units is 390° F. but there have been periods of abnormal furnace operation when these have reached 550 to 800° F.

It is reported unofficially that the raw gas containing 3.5 grains is being cleaned to an average of .2 to .25 grains, and with good furnace conditions, to .08 to .1 grains per cu. ft., all at main conditions.

Prior to the installation of this equipment, raw gas was used in stoves and boilers and as a result a very marked improvement in thermal efficiency and physical condition of these has been reported.



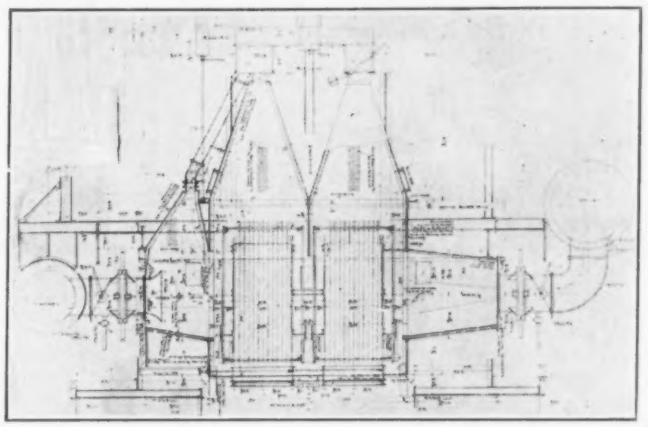
General Arrangement of Six Unit Installation

Tennessee Coal, Iron & Railroad Company, Ensley and Fairfield

At this plant the gases are conditioned with coal tar, usual practice consisting of adding the equivalent of 30 lbs. of coal per ton of pig, in batches of 450 lbs. to every third furnace charge.

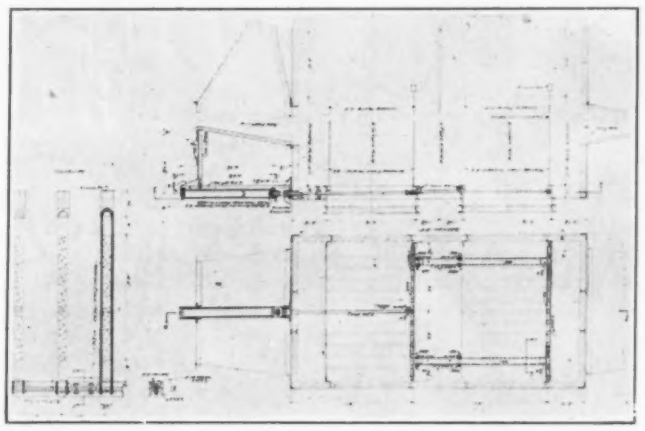
Installed capacity consists of two units, cleaning stove gas on No. 1 and No. 2 furnaces at Ensley, and a battery of six units on the two furnaces at Fairfield. These units are of the horizontal flow type with two sections in series in a single hoppered shell. Each section consists of 12 ducts formed by 2″ thick concrete plate collecting electrodes 14′-0″ high x 6′-5″ wide, spaced on 10″ centers. The dis-

charge electrodes are vertical and are supported from a pipe framework carried on Silica insulators.



Concrete Plate Precipitator for Primary Cleaning

The collecting electrodes are provided with a scraping mechanism for cleaning. This mechanism consists of chains slung around the individual plates and held against the surface by weights at the bottom and supported by a pneumatically moved framework at the top. This frame travels the length of the collecting electrodes and cleans both sections simultaneously. The cleaning operation is accomplished in the space of two or three minutes by simply closing the inlet Butterfly damper, disconnecting the unit electrically and moving the scraper across the section and back. No cleaning of the discharge electrode system has been found necessary.



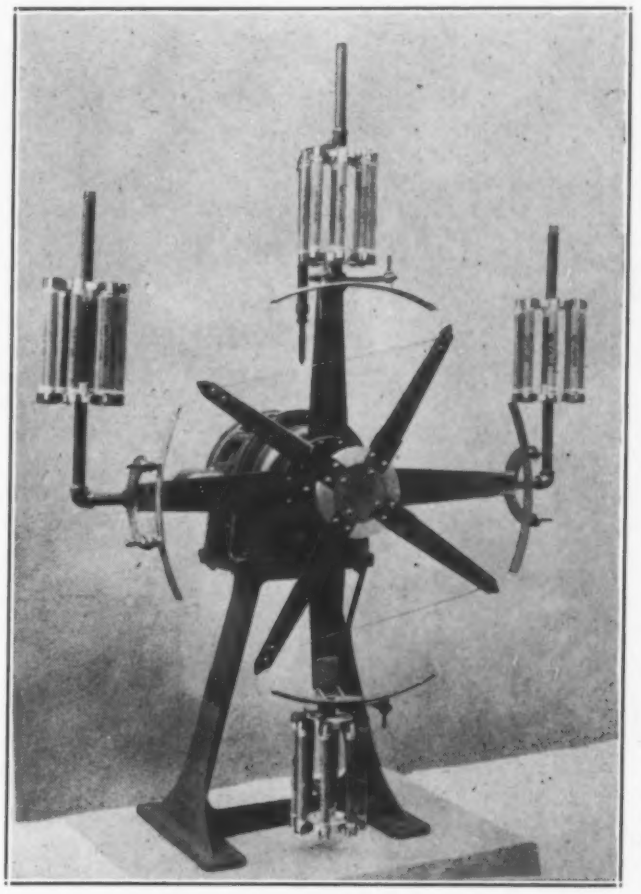
Arrangement of Scraping Device; Concrete Plate Precipitator

Gas flow to the separate units may be regulated by Butterfly dampers located at the inlet and outlet of each. Units may be isolated from the gas flow for inspection or cleaning by means of goggle valves located at inlet and outlet of each unit.

Two inlet sections and two outlet sections are each tied together electrically and powered by separate electrical sets. Each electrical set consists of a 25 Kva transformer with rated high voltage capacity in 5 K. V. steps to 75 K. V., a mechanical rectifier, switchboard and the requisite high voltage switching equipment necessary to secure flexibility of operation.

The average power consumption for the installation at Ensley is 16.5 Kva, equivalent to approximately .9 K. W. H./100,000 cu. ft. at standard.

During the period April 27th to June 8th, 1928, the Ensley installation was under test and, according to test data, treated gas at an average rate of 49,400 c. f. m. at main conditions. The average temperature at the outlet of the precipitators was 414° F., the variation being from 355 to 487° F.



Mechanical Rectifier for Rectifying High Voltage A. C.

Within this period 125 tests were made to determine the content of dust in the cleaned gas and the results showed an average of .156 grains per cu. ft. at 62° F. and 30″ Hg. No test determinations were made on the raw gas but previous experience has indicated that the average is about 2.75 grains per cu. ft.

Aside from bi-weekly scraping of the collecting electrodes, removal of dust from the hoppers and daily inspection of electrical readings, these units operate without any other care.

Difficulties have been encountered in the operation of the Fairfield installation due largely to excessive temperatures. This condition has resulted in insulator difficulties due to the fact that at temperatures exceeding 600° F. the dust at Fairfield becomes electrically conducting. This condition has apparently been overcome but no recent test results are available since operation has become normal.

The temperature of the gas at the precipitator has at times reached a peak of 850° F. The dust content of the raw gas is much higher than that at Ensley, varying from 3 to 5 grains.

Herrenwyck-Lubeck, Germany

This is a recent installation which was erected and placed in operation in September of last year by Lurgi-Apparatebau, who control Cottrell electrical precipitation in Germany. It treats in the primary state, semi-cooled gas, present installed capacity being 30,000 c. f. m. in a single unit.

A split connection after the raw gas main delivers a portion of the gas at a temperature of approximately 400° F., into the top of a cooler where the temperature is reduced by evaporation of a water spray. The reminder is by-passed around the cooler, the final gas mixture being at a temperature of 200° F. ± 10 at the precipitator inlet. This temperature is regulated within close limits by control equipment which controls both the by-pass opening and the pressure on the water sprays. The arrangement is simple in operation and the excess water can be handled in a ¾" pipe overflow.

The primary unit is of the horizontal flow plate type and consists of three sections in series. Collecting electrodes are corrugated steel plates. Vertical discharge electrode wires are hung from insulated frames located above the tops of the plates. An ingenious rapping system driven from a single motor, raps all discharge and collecting electrodes continuously.

Two electrical sets are used to energize, one for the first section and the other for the two trailing sections hooked in parallel. Power consumption amount to .7 K. W. H. per 100,000 cu. ft. at standard.

It is reported that the gases leaving this unit contain not over 0.083 grains per cu. ft. at 62°-30". The precipitate carries a high content of material which is present in the raw gas as a very finely divided fume. It is low in iron and has cementitious properties, but in spite of this and the preliminary spray cooling, no accretions have formed in the equipment. The dust removed from the hopper is dry and can easily be moved in a screw conveyor, but some difficulty has been experienced in pumping to its point of use by a pump.

Electrical Precipitation for Secondary Cleaning

The normal uses for secondary cleaned gas require that it be cooled and since the natural location of the cooling operation is ahead of the cleaner it is evident that no further conditioning is required. Secondary cleaning is an ideal application for Cottrell electrical precipitation, and not only are residual solids removed but also any entrained moisture. There are no secondary installations in this Country at present but the Herrenwyck-Lubeck installation also includes secondary cleaning of the entire gas volume. This gas is being used in stoves, boilers and gas engines, and it has also been piped to the coke ovens for heating.

Interposed between the primary and secondary units is a cooler of the hurdle type. Very little dust separates in this and the outgoing water is practically clear. The gas leaves at approximately 75° F. and enters the secondary unit which is also a three-section unit of the horizontal flow plate type. Collecting electrodes are re-inforced flat steel sheets. A very simple arrangement for water flushing the plates, which is only infrequently used, replaces the rapping mechanism of the primary unit.

All three sections are energized in parallel from a single electrical set and consume less than .5 K. W. H. per 100,000 cu. ft. at standard.

Published reports are that this unit is cleaning below .004 grains per cu. ft. at standard. During a visit to the plant in September, tests were showing .002 and less, and in personal correspondence with engineers connected with the installation, we are informed that recent tests are showing no higher contents.

The precipitate is principally water with enough solid matter to give it a muddy appearance. It flows freely from the electrodes and is removed through sealed overflows in the hoppers.

Selection of Cottrell Equipment

In view of the fact that electrical precipitation is applicable to both primary and second blast furnace gas cleaning, it is apparent that the manner in which it is incorporated in the cleaning system will depend upon end results desired, local conditions, and available equipment. In general, the following provisions will apply.

The present system of cleaning in three steps should remain the same, i. e., preliminary, primary and secondary.

Production of secondary cleaned gas from raw gas in one step is a possibility and is actually being done at Witkowitz. While studies of this application have not been completed, it appears that it ultimately will involve greater capacity outlay than two stage cleaning. This is due to the fact that greater reserve and flexibility, together with rapping systems, must be designed into the installation to provide for the rapping operation. Also, in order to recover the dust dry, which is essential, the operation must be carried out at 200° F., and one cannot take advantage of shrinkage in volume due to further cooling.

Electrical precipitators can be installed in series with the general run of primary scrubbers with which many plants are equipped and which deliver gas at .2 to .5 grains per cu. ft., to further clean this gas to residual contents of from .01 grains down to a trace, depending on final content specified. Such an arrangement involves a minimum of capital outlay and operating charges are of an order that should permit secondary cleaning of all the gas from all subsequent use. In plants already equipped with wet scrubbers this makes a most attractive application.

Where new primary equipment must be provided, electrical precipitation becomes attractive from the standpoints of very low water and power requirements, no sludge problem, minimum resistance to gas flow and gas cleanliness of 0.15 grs. and less, per cu. ft. at standard, depending on amount of equipment installed; there is also the possibility of sensible heat conservation, but this is not believed to be of importance when average temperatures exceed approximately 350° F., and moisture contents are 30 grains or less per cu. ft. at standard. Primary cleaning should include conditioning by coal tar when sensible heat conservation is the main object and by spray cooling when this is not warranted,

and also when there is considerable finely divided material present as fume in the gas. Unless credits can be given for sensible heat, spray cooling has the advantage because of some saving in capital and operating costs due to simplification in precipitator construction, volume shrinkage, and reduction in reserve necessary for furnace irregularities.

When the raw gases are conditioned by spray cooling, there is ordinarily a minimum spread of 50° F. between exit gas temperatures and dew point. Provided the length of unlined main to point of use is not abnormally great, there will be no condensation of moisture and the gas can be used in stoves and boilers without further treatment.

Where the requirements are that a portion or all of the gas be given further treatment, a secondary precipitator may be added with a hurdle cooler between the primary and the secondary units. Depending on amount and cleanliness of primary gas required, the precipitation equipment may be selected so as to place most of it in the secondary stage where some saving may be effected in capital expenditure.

To sum up, therefore, present indications are that one of the principal applications of Cottrell electrical precipitation will be for secondary cleaning after existing scrubber equipment. The other principal use will probably be in combination of all or a portion of the gas in precipitation equipment using in the primary step the spray cooling method of conditioning and minimum equipment necessary to permit uninterrupted operation of the hurdle cooler.

Before closing, I want to take this opportunity of stating that much credit is due the management of Colorado Fuel & Iron Company, together with Messrs. Sykes and Neblett who engineered this installation, and also to the management at Tennessee Coal, Iron & Railroad Company for their courage and persistence in pioneering the two principal installations in this country at present.

Discussion

H. C. Siebert: Gas cleaning is a very interesting subject and I think it is recognized as a very important subject. I think an idea of its importance can be had from the fact that when we consider the modern steel plant—by that I mean the plant of steel works, rolling mills, and blast furnaces—blast furnace gas is the one biggest factor of such a plant. That may be appreciated from the fact that on an average probably 55 per cent of the heat present in the coke, charged into the blast furnace, is available in blast fuel gas.

During some time past I think this point has been given more and more consideration and its importance has been appreciated more and more. I think it is accepted as a pretty definite conclusion that most of the large plants, especially if they also have available surplus coke oven gas, can supply practically the entire plant, at least 90 per cent of it, by the surplus fuels; that is, by the heat present in them, so in that connection blast furnace gas is, therefore, being applied more and more throughout such a plant to the heating of metallurgical furnaces, (soaking pits, heating furnaces, and so forth), while formerly it was only applied to stoves and boilers.

This means, however, that blast furnace gas must be transmitted great distances in order to supply many of the mills demanding a large amount of fuel, and preferably gaseous fuel. To do that means we must distribute the gas over some distance, and therefore we must clean it pretty well. I don't believe a cleaning to 0.1 or 0.15 grains per cubic foot is sufficient. I think we have got to get the gas cleaner than that. I would say such a gas should be cleaned to point 0.05 grains per cubic foot and it should also be dry, of course. It should not be laden with moisture or fine sludge. The difficulty which is being more and more appreciated in connection with cleaning of blast furnace gas by the water method, is the disposal of the sludge that remains. That was usually turned into streams and discolored and contaminated the water. The Government is impressing the importance of that on the industry and we must take steps to remove it.

For that and similar reasons I think it is pretty well appreciated that there is a great field for a dry cleaning system, but whether we clean gas by dry or wet systems, we must do it to a fine state in order to realize the full benefit inherent in it.

The papers were very interesting and brought out many points of general interest to the industry.

Gordon Fox: I was particularly interested in Mr. Hedberg's paper. I think that paper deserves our very favorable comment. It was enlightening and extremely interesting and placed before us the status of electrical precipitation in a very clear manner. At this time, when finer gas cleaning is becoming so active, it is fortunate that we can have so definite a presentation of the possibilities of electrical precipitation. I want to congratulate Mr. Hedberg on his paper.

J. C. Hayes: Mr. Hedberg's clear and able presentation of modern precipitator practice brings to our mind some of the early experiences with precipitators, where attempts were made to treat gas directly from the dustcatchers, that is, without precooling. We happened to be directly associated with the N. H. Gellert Company in conducting operating tests on the first electric precipitator installed in this country for treating blast furnace gas. This was on a ferro-manganese operation and was perhaps an unfortunate choice for demonstrating the process, on account of the unusually high top temperatures and excessive amount of fine fume to be handled.

A great deal of difficulty was encountered in finding a suitable supporting member for the electrodes and in maintaining insulation. In fact the precipitators had to be considerably altered, to the extent of installing insulators and supports in external chambers out of the path of gas. These chambers had to be steam heated to prevent breakdown of insulation, due to moisture condensation. A number of operating difficulties, mostly attributable to local conditions, were met with, nevertheless it was possible to make a striking demonstration of

a really remarkable cleanup when gas conditions were known and kept under control.

With the precipitator on the line and with power on, with correct velocity of gas through the pipes, and with accurate control of temperature and moisture content of gas, a manhole on the side of the precipitator above the top header could be left open and the gas issuing therefrom could not be seen at a distance. With the power off, a veritable cloud of dust was emitted from the same opening. The condition could be reversed with only a few-second intervals, and the evident efficiency of the precipitator was clearly demonstrated. The great difficulty in practice was to control the velocity of the gas and keep a proper temperature and degree of saturation in the raw gas.

In the light of these early troubles, it is extremely interesting to note that there is practical agreement among precipitator designers in that the gas must be conditioned or the temperature must be considerable reduced in order to secure satisfactory precipitation. The value of sensible heat in the blast furnace gas has been stated to be as high as 8 per cent, and practically vanishes under different assumptions, more or less correctly representing average plant conditions. It is probable that an average of some 3 to 5 per cent of the total heating value of the gas could be retained for use at the stove and boiler burners, should it be possible to clean gas by any system retaining this heat.

We are among those who feel that electric precipitation will find its greatest popularity among such plants as are handicapped by scarcity of water, and that plants so located as to have a reasonably cheap water supply will advance in gas cleaning along the lines of the disintegrator.

There is every indication that the blast furnace operators in this country are rapidly arriving at the conclusions reached by European operators some years ago, namely, that all blast furnace gas should be cleaned down to a dust content not exceeding .01 grains per cubic foot for any and all purposes. The only demand for very fine cleaned gas in this country up to 1928 was for use in internal combustion engines. Theisen cleaners of the drum type have been used exclusively for this service, with the result that operators became quite familiar with the method of handling and results were beyond question. For this reason, when a selection of cleaner had to be made for gas to be used for underfiring coke ovens early in 1928, it was decided to use the Theisen drum type machine, as this was the first installation of coke ovens in this country to be underfired by blast furnace gas.

As a matter of fact in Europe, where fine gas cleaning has been necessary for the extensive use in open hearths, coke ovens, heating furnaces, etc., they have not built cleaners of this type for sixteen years. Much has been learned along the lines of power economy, water economy, space requirements and installation costs of gas cleaning equipment. Theisen cleaners are now built on what is called the basket or bar principle, in which closely spaced, horizontal bars in a multiple squirrel-cage rotor, are made to pass stationary bars in the same casing at high speed. Water is fed to a center drum and passes out with the gas between the rapidly moving and stationary bars. A still later development and one showing much better economy consists of a series of closely spaced, corrugated plates, mounted edgewise on a shaft in the same type of casing as the basket type. Water enters in substantially the same manner as in the basket type, and in fact both types are interchangeable on the same shaft and in the same casing.

In general, disintegrators for blast furnace gas are built in units to handle 20,000, 40,000 and 60,000 cubic feet of gas per minute, all operating at 730 r.p.m., using somewhat less than 5 hp. per 1,000 cubic feet of gas per minute, requiring approximately 5 gallons of water per 1,000 cubic feet of gas and cleaning gas down to .008 grains per cubic foot. Gas before entering the Theisen scrubber must be precooled, ordinarily in a static tower of some kind, and guarantees are based on gas entering the disintegrator at .5 grains of dust per cubic foot.

Where gas is to be delivered to the gas holder and thence distributed to points of usage, no moisture eliminators are required, but, as is generally the case, where the gas must be used directly from the cleaning system, it is necessary to install moisture eliminators to remove the particles of dust laden water carried in the gas leaving the disintegrator.

In Europe disintegrators are generally designed to increase the gas pressure anywhere from 5 to 20 inches head of water. This requires a fan element in each rotor. Machines proposed for use in this country will not have fan elements, other than that necessary to overcome the internal friction in the machine itself. Should it be necessary to raise the gas pressure above that which may reasonably be carried back to the blowing engines, separate booster fans would be installed. These separate boosters may well operate at some 60 per cent efficiency, whereas the disintegrators incorporating a booster element, have an efficiency of something less than one-half of this for that part of the power required for boosting the gas pressure.

In Continental Europe every plant, without exception, has some method of cleaning blast furnace gas down to a finer degree of cleanliness than anything done in this country, with the exception of gas cleaning for internal combustion engines, and the recently installed system of underfiring coke ovens.

F. E. Leahy: In calling on various members here the discussion is supposed to be very informal and we are particularly anxious to find out what kind of cleaning you are doing at present in your plant and what you are using the gas for as well as the results you are getting.

Fortunately we happen to be here at Duquesne where I think they have started a good many years ago on this problem and have had some very excellent results. Recently we seem to have been brought to the point where the cleaning formerly considered very satisfactory for stoves we are now given to learn is no longer satisfactory. It would be very interesting to hear how the results are coming out on the new Duquesne stoves, for instance, how they are standing up under the greater capacities. We should like to hear from everybody along this line. You must have some kind of cleaners, almost every-

body does. Just what results are you getting and what are you using the gas for?

I think one of the things that has probably stimulated a lot of thought along this line in recent years has been the diverting of the gas from the boilers into the metallurgical problems. That offers wonderfully attractive possibilities. We used to think the easiest way to waste blast furnace gas was to shoot it through a boiler and up until recent years it was really wasted, but now it is coming into its own. We are talking of spending as much as 50 cents a ton on the coal equivalent basis on cleaning the gas. Are we spending too much? Is it necessary to clean it as much as that?

These are problems that we all have facing us today and we should like to hear from everybody here. Tell us what you have. Don't say you have nothing to say. Everybody can say something of interest, so that when the meeting is over we may all have contributed something. Let's have your problems and jump in on this. We know you would like to get some information.

S. G. Worton: I don't know that I want to describe our gas cleaning outfit in the presence of yourself and Mr. Siebert. I should have to go back to figures most of you gentlemen prepared and as they don't correspond in a lot of cases, I don't want to be the judge. I must say the two papers were very interesting and I was rather disappointed in the discussions.

In my position, as most of you gentlemen know, this gas cleaning plant has been in operation for about twenty-one years and we listened to the different gas cleaning engineers and manufacturers of gas cleaning equipment and we have their arguments one at a time, as you all know, and we discuss them, and put them up to fuel experts whom we have in our own plant and who come from the other different plants, and it is pretty hard to come to a definite understanding of what gas cleaning proposition you want to put in, because you all have different arguments and they are all good. If they weren't good, you wouldn't come around. That is part of the job. But I should like to hear more open discussion of the two papers, and I think you get my point there, Mr. Leahy. I know Mr. Siebert does, because I have heard statements made by fuel engineers and really, they don't agree or come anywhere near agreeing, so I don't want to put my own views down.

I am interested in getting the best gas cleaning applicable to the Duquesne plant and I am up here to get all that is available, so anything you gentlemen will discuss and give me will certainly be appreciated.

F. E. Leahy: I think Mr. Siebert has had a great deal to do with the design of your plant and helping to place it into operation. Personally I feel that you have a good cleaning plant. Mr. Siebert will you let us have your experience in connection with this plant.

S. G. Worton: I think you both should describe it because you both discussed it and criticized it and made different comments and commendations. If I were doing that I should have to send for Mr. Davis and Mr. McLaughlin, to get much data which I am afraid the table wouldn't hold. If you will both discuss it, I shall be very glad to hear it.

H. E. Siebert: I should like to invite myself to this discussion as I think I have received a partial invitation. I have Mr. Worton's permission and Mr. Leahy's suggestions.

It happens that about twenty years ago I was working on a drawing board in his plant and it was my good fortune to get the job from the chief engineer to design the gas cleaning plant, which, I think, many of you will go down and see later on. It consists of nine scrubbers 12 feet in diameter, 72 feet high, and we introduced water at the top through a revolving spray pipe of a cast iron 8 inches inside diameter. The bottom of this pipe had a slot milled through it, 1/8 inch wide, the idea being to obtain a solid sheet of water descending over the full diameter of the scrubber.

We designed it with a view of conserving the power necessary to revolve the spray pipe and to do it we put on a reaction vane at the bottom of the horizontal portion and that served as part of a water wheel when the pipes were properly lined up. We were able to get with five or six pounds water pressure a speed of 35 or 40 r.p.m. We had a five h.p. motor driving this revolving spray pipe. The water was thrown out in the form of a diagonal sheet of water at the outermost portion of the shell, and through a vertical stream at the center of the scrubber. In order to bring that down to a vertical drop—we wanted to obtain the water in the form of a heavy rain—we introduced a series of commercial screens consisting of galvanized wire probably about a half-inch pitch, probably 3/32 wire diameter. Ten or twelve screens were piled on top of each other, with broken joints, and they had the effect of deflecting the water from the diagonal direction to a vertical, also introducing sufficient resistance to break the water up into heavy drops, so we did obtain a very uniform and a very heavy rain.

We had difficulties with mechanical alignment and the operating troubles due to that factor. We had a ball race there which gave us considerable trouble which led to an abandonment of that scheme and to another form of intermittent spray which I think is now used, but the results of that plant have always been very good right from the very start.

From the very start the primary cleaned gas was always very good, no evidence appeared of an excessive amount of entrained moisture being carried by the gas, and the flame was very good; a nice clean, blue color. We also provided fans in connection with the scrubbers. I think you will find in that plant three fans, each of about 200,000 cubic feet capacity, provided with good-sized motors, 200 h.p., so that some water can be added on the fan propeller and the propeller throws the water into a fine spray and further tends to clean the gas and eliminates much of the moisture that may happen to be carried out from the scrubbers. On the discharge side of the fans you will also find moisture eliminators which are big cast iron vertical retorts which also serve as water seal valves, and these have the effect of reducing the moisture and sludge quite a little.

My impression is that the gas leaving these

scrubbers is probably cleaned down to one-tenth or fifteen-hundredths of a grain of dust per cubic foot. This gas, by passing through the fans, is cleaned to about 0.05 grains per cubic foot with which dirt it enters the burners, and my understanding is that in the twenty years in which this plant has been in operation, they have never been forced to the necessity of having to clean the semi-clean gas mains. They have never had any trouble, as far as I know.

In the distributing gas mains there is a number of drains provided for eliminating whatever moisture may collect in the bottom of the mains, and that can be manually discharged without apparently any difficulty. The plant has done good work and always has given a very low cost for the degree of cleaning. I think that Mr. Leahy will agree that even today it holds its own as a very good gas cleaning plant, and I believe it is.

F. E. Leahy: I don't know what I can add to what has been said, but there is one point there about that plant that has always attracted me and more so since I have been getting around a little more. When these scrubbers were running at capacity which I believe was designed around 30,000 c.f.m., the total loss to them was only five inches of water.

As Mr. Siebert said, by passing through the fans where the sprays were carried through, you could even go down to 0.05 but I believe in the campaign on their stoves here they could run for five years and open a stove up and blow her out very little and put her back in operation. Is that right Mr. Worton?

S. G. Worton: Yes.

F. E. Leahy: I see that Mr. Bryant is here. He can vouch for this cleaning of the gas from the scrubbers being one of the smallest parts of his job. I don't recall in my time here there was any particular thing to do at the fire boxes where these were used. These scrubbers were designed primarily for stoves and later used on the boilers. A little detail in the operation came out at one period there when there showed up some sludge around some of the burners and some water. A few checks made on the scrubbers showed some were carrying a greater load than the others. By taking the scrubbers off and giving them regular cleaning depending on the ones that should come off, that eliminated all that and it was the end of that trouble, so my recollection of the cleaning plant which, I believe, is one of the early plants, I think today will compare very favorably with any of the plants since constructed. I think in some cases we are going to extremes and suffering from it. I have known some scrubbers where the loss in pressure runs from fifteen to eighteen inches, compared with the Duquesne of five inches, and what is the reason for it?

R. S. Coulter: We have just the conventional towers with which we do very little cleaning, but add a lot of moisture to the gas.

While I am up I want to express my appreciation of the two able papers presented and incidentally ask a couple of questions, one of which is, in each type of cleaning what could we expect at 15 to 18 grains of dust? How far could we expect to clean it with the Bartlett Hayward method and the others? What can we expect in reduction in fume from ferro-manganese gas?

Chairman Conway: Those are two good questions. Mr. Reed, what are you doing at J. & L.?

L. J. Reed: I don't know that I have anything particular to report for our gas cleaning plant, which consists of Brassert washers. I was very much interested in the timely papers. I think it is a subject that we are going to go into more and more in the near future; with each year showing the iron and steel industry committed more and more to washing gas for boiler use and also tending toward committing itself to the use of blast furnace gas in industrial furnaces a considerably greater cleanness is required than for boiler use.

Most of us have looked at the Cottrell process very much from a distance, so we are interested to get a more intimate picture of it and some news about it. We are more familiar with the tower washer.

I was interested in Mr. Seibert's reference to dry cleaning as some of my Duquesne friends will recollect when I was here with Mr. Wharton, we gave some time to that and I have always felt that a dry cleaner could be developed and had possibilities in it. This would not necessarily be by electrical means, but by mechanical means. With the big use of powdered coal and consequent demand for the control of fly ash we may get in a stimulus from another angle that will benefit blast furnace gas cleaning and, incidentally, I feel that perhaps it will be along that line that we may get our primary steps in mechanical dry separation of dust.

We have apparently made some progress in the vortex type of cleaner and perhaps that is going to lead not only to vortex developed from the pressure of the gas itself, but to a positively driven system which will perhaps permit of smaller space or at least permit of a higher degree of separation.

S. G. Worton: After Mr. Leahy's and Mr. Seibert's discussion I noticed Mr. Riddle come in. He didn't hear the papers the gas committee so thoroughly discussed. I will say for Mr. Riddle's benefit that Mr. Seibert and Mr. Leahy have a very good opinion of it in their description of our plant. I suggest we get Mr. Riddle's opinion.

L. E. Riddle: With the exception of what I heard Mr. Leahy say in the last minute of his discussion I know nothing of what has been said; from his remarks I understand that he thinks our scrubber plant compares very favorably with modern wet washers and I do not agree with him. It is true that we can wash gas in a way, but it is also true that our scrubbers do not take the solids in our gas below .25 and .30 grains. It is true that our stove gas is as good as is used anywhere in stoves, solids in it being only .06-.15, but this is only accomplished by passing the gas from the scrubbers through two fans which use 720,000 gallons of water per day and are really a type of disintegrator. They each require 100 HP to operate. Washing gas for two furnaces we require 7,500,000 gallons of water on the scrubbers and 720,000 on the fans, over 4,000,000 gallons per furnace.

*Bethlehem Steel Company, Sparrows Point, Md.

They are doing as good if not better work than they ever did; were the best to be had when built, but are now obsolete. I say obsolete because many modern wet washers accomplish the same results on the scrubbers alone that we do in both scrubbers and fans using but one-third of the amount of water we use. None of them use over one-half as much as we do. We use 45 to 60 gallons of water per 1,000 cu. ft. of gas cleaned, while modern washers use 17 to 25 gallons per 1,000 cu. ft. of gas and clean it below .1, while ours is but a semi-clean gas leaving the scrubbers; best of it containing .25 solids. Our scrubbers are frequently taken off, cleaned and repairs made. In this age when we must chase the last cent and get our costs to rock bottom the extra cost of operating our washers and fans to get the same results as the modern washers give makes this part of our cleaning equipment obsolete.

F. E. Leahy: About water consumption, there has always been one measure no matter what type of scrubber you use, and that was based at the outlet gas temperature and inlet water temperature and even some of the modern scrubbers are still limited by that same measure, so that in expecting a low water consumption I don't know just how you are going to do it and still hold your outlet gas temperature down.

It depends a good bit on your water temperature what your water consumption runs.

T. A. Lewis: Blast furnace gas cleaning is a pertinent problem with us, because the utilization of this gas releases a high price bituminous coal due to high freight rate. This gas is extended to metallurgical furnaces and because of long gas lines, it is essential that we obtain very clean gas. For stoves and boilers a type of primary washing tower is used. This type is not entirely satisfactory, alough our average run of dust of 0.2 to 0.3 grains per cu. ft. is not excessive insofar as effecting combustion is concerned, so long as there is not present an excessive fume content. This fume content, which consists of lime, potash and alkali cyanides is increased with the ores high in potash. When this fume is present and of sufficient quantity, it will extinguish the fires in the boilers, even when the dust content may not exceed 0.1 grain per cu. ft. We are naturally very much interested in anything which has proven efficient in the removal of these potash fumes, as this constitutes about the most difficult phase of primary blast furnace gas washing.

Walter de Fries: From the exhaustive papers presented here by Messrs. Hedberg and McGurty, and the ensuing discussion it would appear to me that the gas-cleaning problem so far has received most attention from the mechanical and electrical viewpoint.

In reading accounts of similar processes as employed in chemical industries, further possibilities appear to present themselves through the employment of physical and chemical means. I have in mind particularly a process for cleaning hydrogen gas, in the preparation of which water gas is passed through spongy iron ore and dust—similar to that found in blast furnace gas—is thereby accumulated in the gas stream. To rid the gas from these objectionable impurities, it was contacted in thin jets with a surface of a mixture of glycerin and water, which appeared to hold even those fine particles of dust, occasionally observed as motes in a sunbeam and which, as we know, will not be collected by a surface of plain water, due to its high surface tension.

We all have observed soot floating on water without discoloring it, and know that the slightest air current will pick it up without leaving much residue on the water's surface, indicating the lack of adhesive or binding qualifications of ordinary water for fine dust particles.

I believe, therefore, that the development of several dust-collecting fluids will ultimately solve, not only the elimination of fine solid matter from gaseous streams, but may possibly serve also to absorb some of the obnoxious fumes which have just been mentioned. This suggestion points, therefore, to the employment of physical and chemical means in addition to the mechanical and electrical appliances already developed for the ultimate solution of the dust separating problem.

In discussing these possibilities with some of the prominent blast furnace engineers in hte country, they have suggested to go even a step further, and develop a compound suited not only for purifying purposes, but also of benefit for binding the flue dust permanently, so that after discharge from the gas cleaner, the residue could be treated for dehydration and the caked conglomerate used directly in the blast furnace.

A. C. Cummins: I should like to ask what happens to the electrical precipitator when the furnace rolls.

H. E. Siebert: I believe I heard in the paper on the electrical precipitator figures quoted for grains of dust entering the primary collector. I believe there were about three grains quoted. Was that right? I should like to raise a question similar to Mr. Cummins. Suppose, instead of three grains we had fifteen or twenty grains per cubic foot, what would happen?

R. M. Hussey: Speaking of the papers from the electrical phase, I have a few questions I would like to ask in reference to actual operation of the electrical precipitation process in cleaning. What about satisfactory insulator operations? Mr. Hedberg touched on the insulator problem in the cleaning chamber. What again and briefly are the difficulties experienced in maintaining a uniform electrostatic field at the connection electrode?

What difficulties, if any, are experienced in operating and maintaining the high voltage conductor system and what is the type of power transmission system used for this high voltage between the substation and the cleaner connections? And as to safety, what are the hazards involved and what

must employees guard against in taking care of such a system?

C. W. Hedberg: The first question that I will take up is that of high dust content. We have never encountered blast furnace gases that normally run as high as 15 grains at the point where we have taken them for treatment in a precipitator, except at such times when the furnace has moved.

It is rather hard to get a sample that covers only a slip period or a roll period as the time is really too short. However, we did get one on one occasion that I think covers a slip period nearer than any other samples which we have ever taken. At that time the dust content in the raw gas increased from a normal amount of approximately 3 grains, up to 22.5 grains per cu: ft. at standard. There was some increase in volume of gas passing through the precipitator at the time, which resulted in some overload on the precipitator. However, a simultaneous outlet sample showed a dust content of slightly under 2 grains per cu. ft.

At Ensley operation was such that the cleaned gases burned in the stoves with a clear blue flame, and it was possible to determine qualitatively the increase in dust content in the cleaned gases when the furnace rolled. It was observed in a number of cases that the coloration of the flame during a roll was not as great as in adjacent stoves in which the gas was cleaned in a simple type of wet scrubber which was reported to be delivering gases containing approximately .5 grains per cu. ft.

Referring again to the averages of 125 samples, which I spoke of, they were all taken with conditions as they existed, and a number of these include periods of high concentration resulting from furnace movements occurring during the sampling period. In some cases heavy slips occurred, and while the effect of the slip lasted for probably less than a minute, the sample was drawn over approximately a half hour period. As a general rule, such samples showed only a .1 or possibly .2 grain increase over the average dust content given for the group of samples.

In general, I should say that with normal dust contents of 15 to 20 grains, the gases can be cleaned down to the desired limit, but it will ordinarily require more reserve capacity. In other words, it will be necessary to provide more precipitator capacity in order to take care of the higher dust content.

The second question was with regard to cleaning the gases from ferro manganese furnaces. Ordinarily these will run with a hotter top and we therefore believe it preferable to condition the gases by spray cooling to a temperature of approximately 200° F.

In addition, it is a rather difficult matter to design and build a precipitator where materials of construction will be continuously exposed to a temperature of 800° F., which is approximately the temperature of ferro manganese gases. This, also, makes it preferable to cool to approximately 200° F. In my paper I gave you some results showing the effect of spray cooling. These happen to be from some early tests taken in 1916 and the early part of 1917 at Bethlehem, at the time that potash recovery from blast furnaces was particularly interesting. We were precipitating in this pilot unit dust which averaged 6 to 7% soluble potash. This was all present as a finely divided fume and in addition there was undoubtedly some lime fume. As I stated, the average of those tests on spray cooled gas was .017 grains per cu. ft., indicating a rather complete removal of the fumy material.

In Europe where they are cleaning blast furnace gases which contain a fairly high content of zinc and lead present in the gas as metallurgical smoke or fume, it is also the practice to reduce the temperature to approximately 200° F. before treatment in the precipitator. When this is done very high removal of fume particles is secured. If, after treatment, there is too much moisture present in the gases for the uses to which they are to be put, it is desirable to put in a hurdle cooler in order to reduce the temperature and condense out the moisture, and if a more complete cleaning is required they can be put through a secondary cleaner in series.

At Lubeck, where they are getting good results, they have considerable fumy material in the gases. The precipitate from the primary precipitator contains approximately 10% iron, and there are usually 3 or 4 grains of total dust per cu. ft. of gas.

With reference to the insulator difficulties, I would say that at Fairfield and Ensley the installations are essentially identical. For supporting the discharge electrodes both use brick pier insulators which are placed in the gas, and while they operated for a long period in a very satisfactory manner at Ensley, they gave trouble almost from the start at Fairfield. Their Research Department made a number of tests and found that above 600° F. the dust in the gases becomes electrically conductive. As a result a leakage path is established across the insulator, which fuses the dust with the insulator itself and forms a conducting path which must be chiseled out before the pier will again become an insulator. There are two possible remedies for this condition, one of which is to alter the construction and remove the insulators from the interior of the precipitators into a separate compartment located on the top. The other, and the one which has given very encouraging results at Fairfield, is to increase the height of the pier in order to provide a longer leakage path to ground. The objection to locating the insulators in an outside compartment is the possibility of moisture condensation, provided the gas temperatures go too low, which in turn might cause insulator leakage. This possibility was the controlling reason for putting the insulators inside in the first place. It can, however, be taken care of in the outside compartments by installing steam coils in order to keep the compartment temperature well above the dew point of the gas.

Except for the difficulties with high temperatures, insulation problems on blast furnace precipitators are simpler than on almost any other type of application.

I have gone into the difficulties resulting from the lack of field uniformity. It results from a lack of uniformity in the precipitated material, i. e., it is due to the mixture of non-conductive iron ore dust and the conducting coke dust. In order to make the electric field uniform it is necessary to make the deposit or precipitate on the collecting electrode uniform, and as I stated, there are two

ways of doing it. The first is to bring the gas temperature down to a point where the precipitate will absorb moisture from the gas. Sufficient moisture absorption to make the whole deposit uniformly conducting can be secured even though the temperature of the electrode deposit is appreciably above the dew point of the gas. When the deposit is made uniform in this way it is about the same thing as a clean, plate collecting electrode without any dust deposit. Just how the tar brings about this effect we do not know but there is a certain amount of tar actually precipitated along with the dust. It is, however, very small. You can determine its presence by analysis and by igniting some of the dust, but its presence is not apparent from the physical characteristics of the precipitate. It is not gummy or sticky, but on the contrary, it is fairly free flowing and does not give any greater difficulty due to sticking in the hoppers than does dust precipitated from the gas without any tar present.

The high tension line from sub-station to precipitator is usually of simple construction. We normally use a pipe carried on insulators, and enclosed in sheet metal guards. We have also used insulated cable, but this is not economical, especially when the lines are short. The line is entirely enclosed and insulators are large enough to stand up under almost any conditions. With insulators protected from the weather, and as long as the dust remains dry, there is very little insulation difficulty on lines. In acid plants we have had some difficulty so these require especial care.

With reference to the hazards from the high voltage utilized, one of the first questions usually asked by a visitor to a Cottrell plant is with regard to location of the dangerous parts. There is an element of danger, of course, but during the entire time that precipitation installations have been in operation there have probably been three or four fatalities due to contact with live conductors. In the first place, the current flowing is very low so that if a man does come in contact it does not necessarily mean that the shock will be fatal; rather, the indications are that this will result only from continued contact.

We know of one case where a man was in contact for possibly 15 minutes or more, and he lived —although it required a long stay in the hospital.

All live lines from the substation to the precipitators and all other live parts are completely enclosed in grounded containers, and it would be impossible for workmen to come in contact with a live conductor without deliberately opening a door or something of that sort. In a number of installations additional safety precautions are taken by installing a system of interlocks which makes it necessary to open the high tension switches and ground the live parts before access can be had to any live conductors, so that essentially there is very little danger connected with the installation in a plant unless a man deliberately makes contact.

L. E. Riddle: At the City Furnaces of the Carnegie Steel Company we have been making a study of Electrical Precipitation of dust and have asked the Research Corporation to work with us on an experiment to see if we can successfully clean ferro-manganese gas by this method. For years I have thought that there were possibilities in the cleaning of blast furnace gas by this method, but a great many obstacles encountered, brought slow development. We believe it is now at a point where we can try out electrical percipitation on the dirtiest of blast furnace gas—that means on a furnace producing ferro-manganese. They say we must cool the gas which leaves the furnace at from 500 to 900° down to 200°. This gas must not be saturated, must be kept above the dew point and not carried over any entrained moisture. This gas carries a fume which is quite different from anything in pig iron gas, and unless it is thoroughly washed in the cooling I am afraid there will be a building-up of hard dirt not only in the primary cooler, but in whatever follows. When this dust builds-on it gets as hard as cement; it takes a thorough wetting to keep it from doing so, whereas basic or Bessemer blast furnace gas does not harden quickly and can be moved by a small amount of water.

C. **W. Hedberg:** Ordinarily there will be a spread. I do not know what the initial temperature is, but I feel quite sure that there will be a spread of 40 to 50° F. between the dew point after spray cooling and the actual gas temperature, so that the gases will be well above the dew point. We have operated a number of installations in this manner. In some cases there has been a spread of only 30 to 33° between gas temperatures and dew point —yet the precipitated dust has been in a dry condition, and I am inclined to think that the same condition will occur there. As to the hardening of the material, the spray cooling method of conditioning is being used at Lubeck and there the precipitated material is taken from the Cottrell precipitator as dry dust and sent to the cement plant where it is mixed off with finished cement.

W. J. McGurty: Mr. Coulter's question, I believe, was also asked by several other gentlemen, that is, "the effect of an increased dust content on the cleaning results with our apparatus." We have scrubbers operating in all of the iron producing districts of the country, and one installation in particular where the dust contest, on a monthly average, was approximately 16 grains per cubic foot, with periods when it increased to 35 or 40 grains entering the scrubber. Such increase, however, did not affect the dust content in the outlet gas.

Personally, with the proper means for applying the principles involved in wet cleaning, I believe that we do better cleaning when the furnace is rolling, than under ordinary normal pressure conditions. At such times the water temperature increases 50 or 60 degrees, its viscosity is reduced, its dust content increased, and it is our theory that it is easier and better to clean the raw gas with thin sludge than with water, for the wetted dust particles provide a nucleus for attracting the fine dust particles in the raw gas.

This was the basic principle of our design, for by diverting a large portion of the water from the upper or cooling stage, the liquid in the dust removal stage is hot, and its effectiveness increases with its temperature, as a finer and better distributed spray is produced.

In the tower type of washer, the water is often only heated ten or fifteen degrees above its entering

temperature, consequently it is not as hot when it meets the raw gas as in the mechanical scrubber, which is a measure of its comparatively lower cleaning results.

Mr. De Fries spoke of the effect of adding glycerin or other chemicals to the scrubbing liquid to secure better cleaning results. We have proven in our research department, during the past four years, that there are a number of chemicals which when added to the scrubber water will materially change surface tension conditions, but their use would depend on the cost of such materials when handling large volumes of gas.

This would explain why, in Mr. Hedberg's operation, a better conditioning is secured by charging coal to the furnace, since tar oils have been successfully employed in the flotation industry.

In our five years' experience with cleaning blast furnace gas, and my twenty years' experience with various gas cleaning operations, I feel that it is more complex in character than any other type of gas. In the eighteen years since the first Feld Scrubber was started in this country, we have treated practically every variety of manufactured gas and have found them to be more or less of definite constitution. You can look at blast furnace gas now, however, and five minutes later it may be of an entirely different character.

The main objective in the design of our spraying device was to secured the advantages of the various physical factors existing when a finely divided water spray is produced. We know that the electrical charge generated in the water particles when the high velocity spray is broken up by impact, increases with the intensity of impact as well as the temperature, and I feel that we are utilizing these factors to a greater extent than any other type of wet cleaner.

Mr. Lewis spoke of having at times 0.20 grain gas at Bethlehem, and still not being able to burn the gas. This is due to a mechanical emulsification of the gaseous carbon, by means of the finely divided dust and fume particles, and Mr. Wysor when at Bethlehem demonstrated that the introduction of finely divided salt into the gas supply to a burner would immediately put out the flame. In cleaning gas from basic or Bessemer furnaces we can clean to from .04 to .08 grains per cubic foot in the primary cleaner.

The next type of gas is that from foundry or high silicon iron production, where the same apparatus will clean to about .10 to .12 grains per cu. ft.

For ferro-manganese operation, our design calls for a greater number of contacts, with additional features of design to bring the "fume" particles into more intimate contact with the water.

Mr. Riddle asked the comparative water requirement of the tower washer and our mechanical scrubber. This will depend somewhat on the gas and water temperatures and largely on the amount of water vapor in the raw gas.

In southern practice this content will average from 20 to 30 grains per cu. ft., while in this district an average of 50 to 60 grains with a maximum of over 100 grains is the usual condition. Its reduction, or condensation, represents the greater part of the duty performed by the water used in the scrubber and we all know that the flame temperature of the gas is increased proportionately as the water vapor is reduced. With this 50 grain gas our average yearly water rate per 1,000 cu. ft. is around 17 or 18 gallons, ranging from 13 to 14 in winter to 20 gallons under summer conditions.

The water requirement per 1,000 cu. ft. would naturally be higher on ferro-manganese gas, but I feel that the above data will cover the general operating conditions, and represents from one-third to one-half the water volume needed in various types of tower washing equipment.

The first blast furnace cleaning job that the Feld Scrubber was applied to, was on the gas from furnaces engaged in smelting pyritic copper ore in Tennessee. This gas contained a large amount of zinc oxide "fume," these particles having a high surface tension, and were so light in density that they would travel for forty or fifty miles before being precipitated from the atmosphere. This material was successfully removed in the scrubbing operation.

I may have missed some questions, and would be glad to answer any you may have in mind.

I. A. Nicholas: I came in too late to hear a reading of the papers, but I have been very much interested in the discussion. I have a question I should like to ask. Is the sludge problem after the scrubber due to the gas being saturated with water a serious problem if that gas were conducted say two hundred feet to the boiler house and if it is a problem, it is practical to consider the pre-heating of that gas with the raw gas after leaving the scrubber?

W. J. McGurty: That all depends on the type of equipment you are thinking about. Our oldest scrubber installation in this district has been cleaning down to below 0.10 grain for over three years, and I have never heard of any mains having to be washed out during this period. The drying of the gas is as essential as the cleaning, and we recognized that in our original design of the scrubber. We have a drying chamber in the top, in which the finely divided mist or fog is coalesced into large drops most of which are precipitated in this chamber and returned to the top section. A collecting pot or separator on the outlet nozzle catches any particles that are no collected in the drying chamber itself.

Tests made on the finished gas, within the past few months, show from 0.3 to 0.5 grains in excess of the water vapor due to saturation at the final temperature. Under ordinary Summer conditions the mains would be heated up enough to revaporize this quantity, but, however, dust of the 0.10 or less variety will not be dragged down even with condensation in the main, as the colloidal fume particles have a density often less than that of the gas.

With gas carrying over 0.10 grain there will be sludge in proportion as this content is increased, as there is always some condensation in the mains due to the variation between the gas and atmospheric temperatures, except in the Spring when the water is usually colder than the air and this action is reduced.

I. A. Nicholas: There would be no problem washing down to a tenth of a grain?

W. J. McGurty: With gas of this quality, the condensed water will be quite clear, because the dust particles which have a ratio of 1 to 5,000 of gas will tend to travel with the gas rather than be precipitated.

I think Mr. Seibert referred to the difficulty of disposal of the sludge, which was the principal trouble with wet cleaning on the tower washers. The colder outlet water, with its high velocity through the settling basins, was bound to carry dirt out of these basins. The development of sludge recovery appartus has almost kept step with the development of the gas cleaner, and at present, I would say that the means available for concentrating sludge have entirely eliminated earlier difficulties. It is merely a question of installing the right kind of equipment.

J. E. Dunn: To what extent is drying carried out in your process?

W. J. McGurty: After the gas leaves the topmost spray, it passes between vanes that are installed on the underside of the drying-chamber bottom, and so set as to impart a whirling motion to the gas. In the drier or eliminator the mist or fog impinges on baffles and is precipitated in the form of drops, due to coalescense of the mist particles, and it is purely a mechanical separation.

J. E. Dunn: What percentage of moisture do you get out by that means?

W. J. McGurty: The first drier of this type was installed at Carrie Furnaces and measurements showed that about 7,000 gallons of water per day were precipitated in this chamber.

As stated, with a water input of one and one-half to one and three-quarter million gallons per day we have less than one grain excess per cubic foot above the saturation at 70 degrees, or with a saturation of 8 grains there would be less than 9 grains total.

W. J. McGurty: We have cleaned bituminous producer gas, which, I think, is second to blast furnace gas as regards the difficulty of cleansing. The tars leaving the producer, as vapor, consist of the higher tar oils, which if not removed will condense in the distribution system as pitch, and carbon.

The difficulty I have observed with some systems, is that the towers, which precede the final extractors, are flooded with cold water so that the pitch is precipitated in a plastic form causing stoppages, etc.

Our first operation of this character was at the Mississippi Glass Company's plant at Floreffe, Pa., where this gas was to replace natural gas for lehr heating, and any carbon particles would cause bubbles in the glass which did not receive a final polishing.

We took gas directly from the raw collecting main, putting it first through a small wash box which also acted as a water seal, and were able to clean it in a five section scrubber to the desired quality. With the outlet water at 90° to 100° F. the tars will float, but when chilled they will sink.

It is a difficult cleaning proposition but it has been done.

R. S. Coulter: What is the percentage of the curve?

C. W. Hedberg: The rate at which the dust falls through to the hoppers is greater than the velocity of the gases through the precipitator—although I do not know offhand what the actual percentage is. There is, however, very little disintegration. I have seen lumps detach themselves from the plates and fall through to the hopper almost intact. Some of this material, of course, is carried along into the second section of plates, but that gets less dust.

Question: One serious drawback has been the disposition of the dust, such a large quantity and such fine dust. I wonder if Mr. Hedberg would briefly tell us how they are disposing of that.

C. W. Hedberg: At Birmingham the iron content is too low to make it worth while to sinter, so that they are hauling all of it to the dump in cars. At Fairfield it is sluiced to the dump.

W. B. Chapman: I presume it will not be out of order to inject for a moment the question of washing producer gas. Most of our discussions today have been a recital of our successes, but when it comes to cleaning producer gas we can only tell of our failures; for the problem is very difficult and has not been adequately solved.

I should like to ask if anything has been accomplished with either of the processes under discussion by way of cleaning producer gas, but before it is answered, I should also like to make a few remarks on the subject.

Twenty-five years ago when it was found that producer gas was suitable for gas engines, a great many attempts were made to wash the gas free of tar and soot, but out of all the experiments made, only two washers have resulted. There are only a very few installations of either one in operation. Producer gas from Bituminous coal is very cheap and suitable for many purposes for which it is not used, the reason being partly the cost of the equipment and partly its lack of reliability.

The nearest approach to a clean producer gas from Bituminous coal was the up-and-down draft Loomis-Pettibone producer. A clean, tar-free gas was obtained because the gases were drawn downwardly through the firebed from top to bottom. But the process was finally abandoned because of expense and lack of reliability. Recently I have had some experience with a new type of gas cleaner or dust collector. It is of the cyclone type, but is three times as slender as the ordinary cyclone collector and hence is more nearly like a true cyclone, which probably accounts for its remarkably high efficiency for other purposes. We gave the device a very thorough trial on hot producer gas, both at low capacity and at high capacity, but it did not clean the gas hardly at all. It threw out the coke and gritty particles, but the soft black floculent soot was not removed to any appreciable degree.

A properly constructed underfeed gas producer might give a gas that with this method of cleaning could be rendered suitable for conducting a long distance through small pipes without difficulty, and in many small furnaces would give a greater amount of heat per dollar than can be obtained in any other way.

Because it is (or at least should be) so much cheaper than oil, I am still interested in washing producer gas, and if anything has been tried along that line, we would, I am sure, be interested in hearing about it.

C. W. Hedberg: In 1915 I think it was, the Minnesota Steel Company installed a stand-by cleaning plant for cleaning the gases when they shifted open hearth producers into gas engine service. As I remember it, there was a simple tower scrubber followed by an Ernst scrubber and a booster, but they were getting into difficulties from gumming up of the intake valves. They installed the Cottrell for final cleaning and so far as I know it is still in operation, though just for stand-by purposes. It did remove residual tar to the extent that they had no further difficulty in using the gas in their engines.

We have done some work on cleaning both bituminous coal and coke producer gases while still hot. The hot producer gas made from coke was for use in under-firing vertical coal gas retorts, and it worked out very satisfactorily. We were also able to clean the gases from producers fed with bituminous coal but it appears that such an operation on a commercial scale would be a very expensive proposition. The soot recovered weighs in the neighborhood of 1 lb. or .8 lb. per cu. ft., and as a result it is very hard to hold it on the electrodes after it has been collected.

Installations have been made from collecting carbon black and lamp black from gases at a temperature of 400° F., and these are showing better than 98% recovery. To adapt such an installation for cleaning producer gases where it is necessary to retain all the sensible heat requires very expensive construction. Therefore, it is not so much a case of not being able to do it as being able to do it economically.

New Blast Furnace Power Plant--Fairfield Works Tennessee Coal Iron & Railroad Company

By J. M. SPRAGUE*

A new power plant was put into operation in June, 1928, by the Tennessee Company at its Fairfield Works. This power plant was built with the principle idea in view of consuming the surplus gas from the Blast Furnaces and converting it into electrical energy.

The power plant was constructed adjacent to the two new blast furnaces and consists of a modern boiler plant housed in a steel constructed building, and a power house built of brick in which are installed three turbo-blowers and two turbo generators for producing electric power. These main units are equipped with surface condensers and other necessary auxiliaries including circulating pumps and cooling towers.

Many interesting features of the latest design have been incorporated in the building of this plant in order to obtain the highest efficiency both in the steam generation and steam using equipment.

Boiler Plant

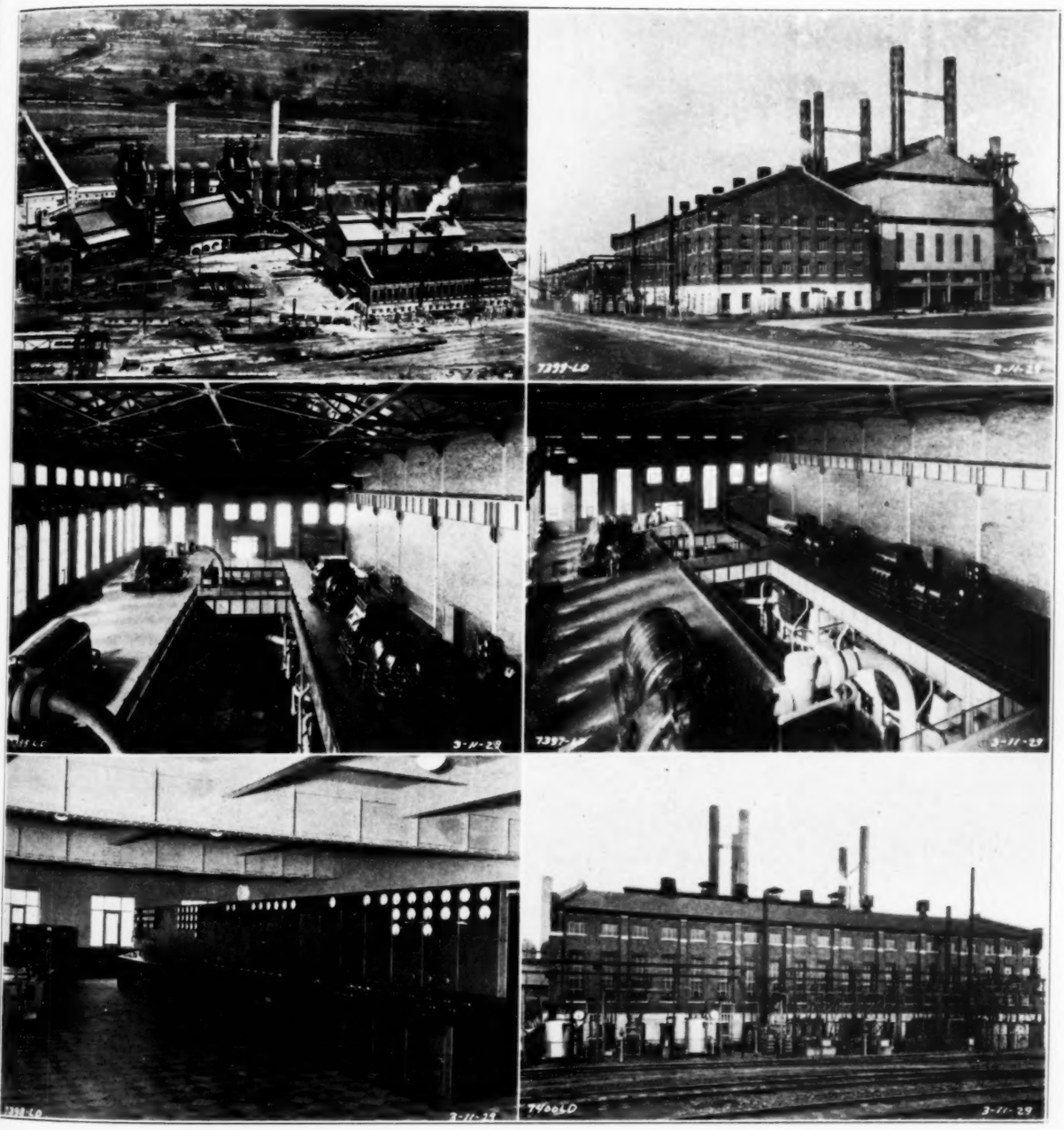
A sectional view of one of the boilers is shown in Figure One, which gives the arrangement of the forced and induced draft fans, the stack and the powdered coal bins. The boiler plant consisting of five Stirling type boilers furnishing steam for the turbo-blowers and generators, their auxiliaries and the miscellaneous uses around the blast furnaces. These boilers have three 42" steam drums and one mud drum. Each boiler has 14,607 sq. ft. of heating surface and a furnace volume of 12,000 cu. ft. and operates at 350 lbs. gage pressure and 200 degrees superheat. The boilers are equipped with two-drum economizers having 10,601 sq. ft. of heating surface, hollow side walls, flat arches, water cooled front walls, water cooled back furnace floor, superheaters with heating surfaces of 2,337 sq. ft. located between the first and second passes, air heaters of the tubular type with heating surfaces of 11,781 sq. ft. located back of the economizers, soot blowers, and steam purifiers in the top of the outlet drums for the removal of moisture in the steam.

All the boilers burn blast furnace gas, but four of them are also equipped to burn powdered coal during periods of gas deficiency. Two gas burners and three powdered coal burners supply the fuel near the bottom of the boiler, the coal burners being about five feet above the gas burners. The coal burners are fed by six 5½" single type coal feeders hand controlled from the main operating floor at the water column level.

The boilers are arranged in two rows parallel to the power house with the fronts of the four coal burning boilers grouped together. This simplifies their operation and better fits the space provided, considering future extensions.

The water columns, automatic control equipment for the control of the forced and induced draft fans, and the instrument boards are located in the aisle between the boilers. Each boiler has an instrument board on which is a steam pressure gage, recording

*Steam Engineer, Fairfield Works, Tennesse Coal, Iron & Railroad Co., Subsidiary of United States Steel Corporation.



General Views of No. 5 & 6 Blast Furnaces, Power House, Main Generating Station, Load Dispatchers Room, and Out Door Substation, located at the Fairfield Plant of the Tennessee Coal Iron and Railroad Co. at Fairfield, Ala.

steam flow meter, a five-point multiple pyrometer which records the temperature of the superheated steam, the stack gases leaving the pre-heater and the pre-heated air just before it enters the coal and gas burners. Two Multipoint draft and pressure gages are mounted on the same board to indicate all drafts and pressures of importance to the boiler. On the fifth boiler, which is fired with gas alone, a recording Co_2 instrument is also installed on the gage board to analyze the waste gases in the third pass of the boiler.

Forced and induced draft fans are located on the top floor of the boiler house. These fans are driven by high pressure geared steam turbines which exhaust into a line supplying steam to heat the feed water. The exhaust line is equipped with a back-pressure valve that operates at about one-half pound pressure with atmospheric relief. The induced draft fans have automatic controls both on the speed and stack damper, which respond to regulators connected to the main combustion chamber. The forced draft fans also have automatic controls that respond to

General View of the Various Units Comprising the Steam Plant located at the Fairfield Works of the Tennessee Coal Iron and Railroad Company, located at Fairfield, Ala.

the pre-heated air pressure desired for proper combustion at the burners. The induced draft fans discharge into an 8'-0" diameter stack with a height of 145 feet above the gas burners. These fans have a capacity of 120,000 cu. ft. per minute at 8" static pressure and a speed of 542 R. P. M. The forced draft fans draw warm air from the pipe alley between the boiler house and the power house and discharge it down through the pre-heaters and hollow side walls of the boilers to the gas and coal burners. These fans have a capacity of 60,000 cu. ft. per minute at 5" static pressure.

There are also installed for the use of powdered coal burning, two primary air fans located on the same level with the first floor of the boiler house on a concrete floor over the pipe alley. These fans are also driven by high pressure geared steam turbines the exhaust of which is used to heat the feed water. These fans have a capacity of 60,000 cu. ft. per minute and have a speed of 760 R. P. M. and 6" static pressure. Only one of these fans is kept in operation at a time and is equipped with automatic control located on the boiler operator's floor

so that the necessary air can be supplied to coal feeders for use during low gas periods.

Each boiler is connected to main steam headers in the basement with an 8" line equipped with a gate valve at the header and a non-return valve at the superheater outlet near the boiler.

The boilers are supplied with gas from the furnaces through an 8" diameter main. The gas is sent through electric precipitators where it is cleaned for use in the stoves and boilers. On the main gas line at the boilers are installed two automatically controlled gas bleeders connected through a master control to open and close with the steam demand.

The gas burners on each boiler are equipped with automatic controls set to maintain a constant predetermined pressure on the main gas line by opening or closing a butterfly valve in the gas burner. This control also regulates the air volume to the burners to give the proper proportion of gas and air for good combustion.

All automatic regulators with the control system, are operated by oil pressure passing through pilot valves to power cylinders. The oil storage tank and filter are located in the basement of the pipe alley. Two steam driven oil pumps supply the oil to the entire system.

A sluicing system is provided for the disposal of waste material from the combustion chambers and hoppers under the economizers and air heaters. Two 2,000 G. P. M. motor driven pumps are provided for sluicing the refuse and ash through concrete cast iron lined trenches to a sump at the end of the boiler house where this refuse is loaded into cars. These pumps take their suction from the refuse sump so that the water can be used again. Boiler blow-off and other wash water is run into this system to supply the necessary make-up water. There is also an emergency make-up connection from fresh water mains provided at the pumps.

Powdered Coal Plant

The powdered coal plant is located about 500 feet from the boiler house. It contains two 6-ton per hour mills of the air separating type, two steam dryers, an exhauster, dryer collector, coal bin and a vacuum cleaner. The powdered coal is delivered to the boiler bins by means of a 5" transport line. There are located above the operators' platform, to supply the four boilers grouped together with powdered coal, four bins of a capacity of 45 tons each.

A cross section of the Power Plant is shown in Figure Two. Space has been provided between the turbines and boilers to accommodate the feed water heaters, pumps, etc., and to serve as a pipe gallery. There are installed in this space on a floor above the feed pumps two deaerating type feed water heaters with a capacity of 500,000 lbs. per hour each.

For the boiler feed equipment there are three 5-stage centrifugal pumps with a capacity of 1,100 G. P. M. at 910 ft. head. Two of these pumps are steam driven and one has an electric drive. The feed pump control has an excess pressure governor on the turbines. The feed water is delivered through feed water regulators to the boilers. The boiler feed system is as follows: Condensed steam from the surface condensers on the main blower and generator units is pumped by the condensate pumps to the open heaters. An elevated 30,000 gallon tank located above the heaters receives any surplus feed water. This elevated tank is provided with an overflow to a concrete tank or sweet well located in the basement between the boiler and power houses. This sweet well is also supplied with a connection from the Open Hearth feed water treating system for make-up, starting and emergency use.

This boiler plant is also connected to the Open Hearth waste heat boiler plant by an 8" underground line. This connection was made in order to take the surplus steam from the Open Hearth and supply the condenser auxiliaries in the power house. This would also reduce the necessary feed water make-up from the Open Hearth treating plant.

The steam pressure carried on the boilers and all main units, as stated above, is 350 pounds. In the basement of the power house there are two steam pressure reducing valves that reduce the pressure to 175 lbs. for use on the condenser auxiliaries, soot blowers and blast furnace direct uses. This line is also tied in with the Open Hearth system.

Power House

The Power House is a brick building that accommodates three turbo-blowers, one a spare, and two turbo-generators on the main floor. All the condensers, pumps and other auxiliaries are located in the basement. Two bays of the power house are separated from the main turbine room by a brick partition. In this section are four floors; the main switch and battery control room on the main floor, the main operating and switch board room on the second floor, with offices on the third floor.

Turbo-Blowers: Each blower has a capacity of 75,000 cu. ft. of air per minute when operating at 30 lbs. pressure and 70 degrees Fahrenheit, with a maximum speed of 2,900 R. P. M. They are four stage type with a 60" intake and 42" discharge, driven by a twelve-stage turbine using 60,000 lbs. steam per hour, at 325 lbs. gage pressure and 200 deg. superheat. Each blower has a three-pass surface condenser located directly under the turbine with 10,000 sq. ft. of surface. Each condenser is equipped with two condensate pumps, one electric and one steam driven, with one being used as a spare. The circulating pump of the dual drive type has a capacity of 7,000 G. P. M. pumping against a cooling tower head of 55 feet. Each condenser is also supplied with a two-stage steam jet air ejector. A venturi tube governor is employed to maintain a constant volume of air. The governor is corrected by hand for variations in temperature and barometric pressure. A graduated manometer scale enables the operator to correct for these two factors.

The gage board is provided at each turbo-blower and generator and is equipped with a recording air volume and pressure meter, a recording steam flow meter and a recording gage and an indicating mercury column gage. Also in the basement, each condenser with its pumps are provided with gage boards equipped with recording thermometers showing the temperature of the water leaving the condenser, the temperature entering and leaving the turbo-blower jackets, also flow meters showing the volume of water circulated through each blower jacket, and

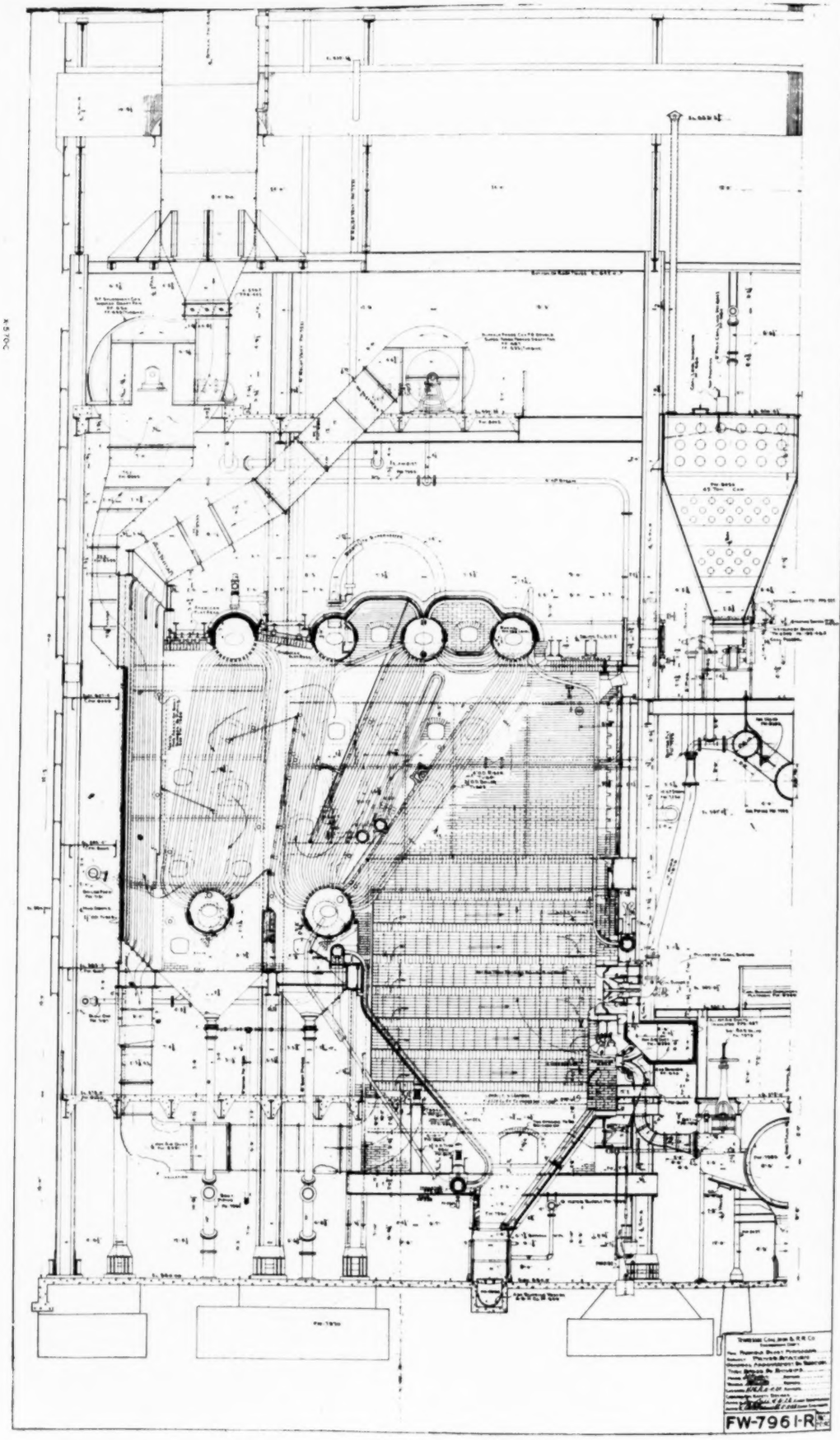


Fig. 1.—Sectional view of the Boilers at the new Power Plant, Fairfield Works

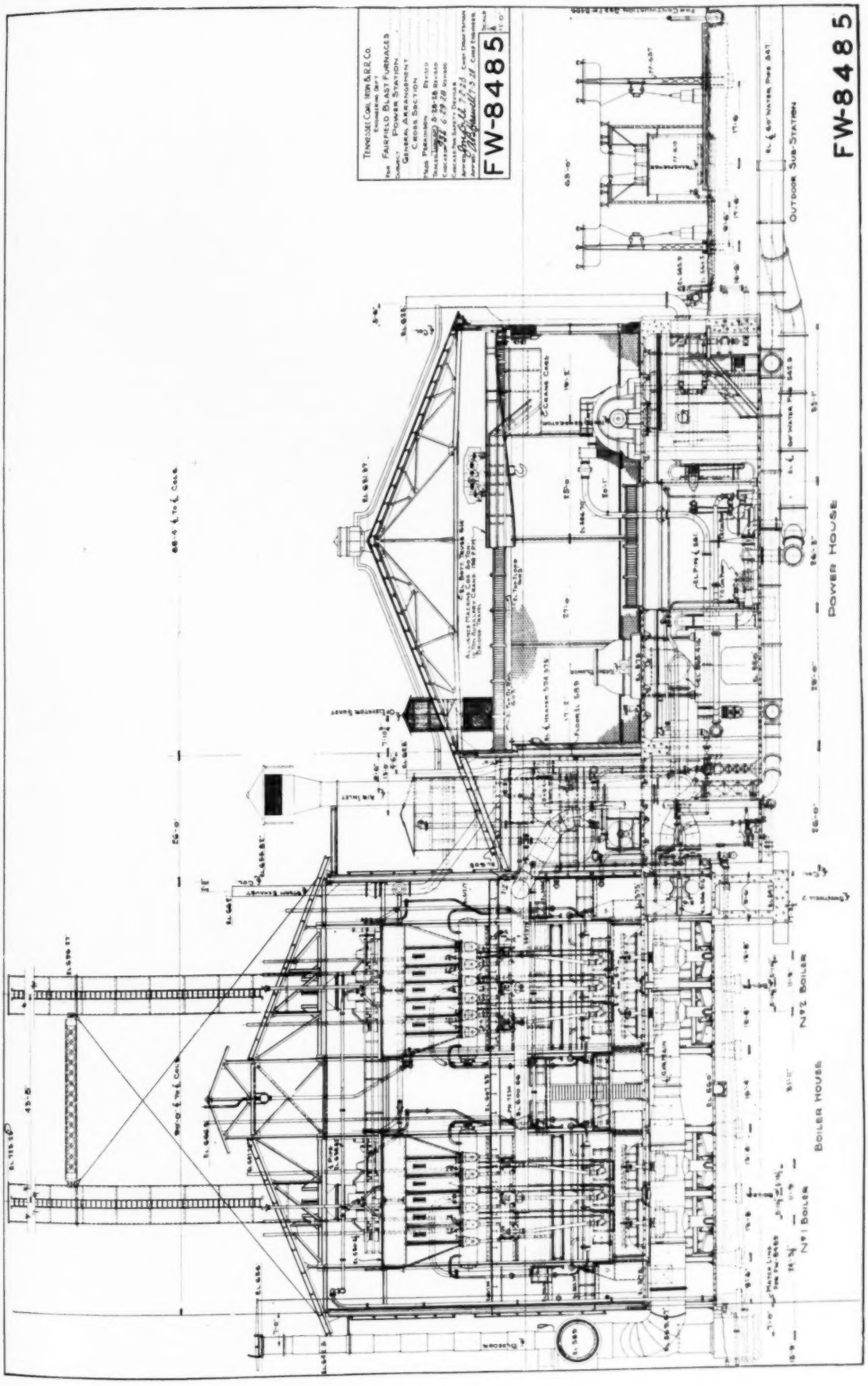


Fig. 2.—A Cross Section of the new Power Plant, located at the Fairfield Works

all other necessary indicating pressure and vacuum gages.

A common oil reservoir and filter is provided in the basement for the use of all the main units using turbine oil.

Turbo-Generators: Each generator has a capacity of 20,000 K. W. at 80% power factor and operates at 1,800 R. P. M., three phase, 60 cycle, 13,800 volts and is driven by an eight stage turbine using steam at 325 lbs. gage and 200 degree superheat. A closed ventilating system is used.

The generators each have a three-pass surface condenser with 30,000 sq. ft. of surface. Each condenser is equipped with two electric-driven condensate pumps, one as a spare. Also one dual drive circulating pump is provided with a capacity of 21,000 G. P. M. against the cooling tower head. These condensers are also supplied with two stage steam jet air ejectors.

The circulating water for the condensers is pumped to three batteries of natural draft cooling towers located about 1600 feet away. The discharge and return lines are steel pipe 60" in diameter.

The main condensers are located below the water level in the cooling tower basin and the water flows through the condensers by gravity and to the pumps

General View of the Coal Pulverizing Plant, Water Treating Plant and Cooling Towers used in connection with the new power plant at the Fairfield Works.

which return the water to the towers. This arrangement simplifies starting and assures water in the condenser at all times. Make-up cooling water is supplied through a treating plant which consists of a raw water storage or settling tank, chemical treating tanks and pressure filters. This is a continuous treating and filtering system with a capacity of 1,000 G. P. M. This equipment was installed to eliminate the cleaning of the condenser tubes as the treatment should practically eliminate the scale-forming constituents in the water. The present treatment consists of hydrated lime and ferrous sulphate. It should be noted that the water circulated in the cooling towers becomes concentrated due to evaporation at the tower, and during the hot summer months, without some method of prevention there will be a deposit of scale on the condenser tubes. This scale would also be deposited in the generator air coolers, transformers, lubricating oil coolers and turbo-blower jackets.

There are located in the power house basement additional circulating pumps with storage tanks and return sumps that circulate the water to the blower jackets, oil coolers, bearings, etc. This system is also inter-connected with the cooling tower system.

The plant is supplied with direct current by two motor-generator sets (one spare) of 750 K. W. capacity. Each set is equipped with full automatic control on A. C. and D. C. sides. An outdoor type sub-station is located adjacent to the power plant, the principle equipment being the 25,000 K. V. A., 13,800 to 44,000 volt, three phase, 60 cycle transformers, and three 1667 K. V. A. 44,000 to 6,600 volt, single phase transformers. The 25,000 K. V. A. transformers are cooled by an oil circulating system, the oil in turn being cooled by water in an external oil cooler. Current is sent out at 44,000 volts through underground cables to another sub-station from which it is distributed to the other works.

FAIRFIELD POWER PLANT OPERATING RECORDS

Comparison of Results of One Week's Operation, Two Generators in Service, with the Month of January, 1929

	Month January	Week Jan. 7-13
Average number of Boilers in Service	3.27	4
Average B. H. P. per Hour in Service	4,780	5810
Average B. H. P. per Hour Generated	17,680	23,069
Average per cent. of rating	370	397
Average Steam Pressure Lbs. Gauge	338	334
Average Steam Temperature leaving Boilers, Deg. F.	433	432
Average Steam Temperature, Leaving Superheaters, Deg. F.	642	653
Average Degrees Superheat, Deg. F.	209	221
Feed Water Temperature—Leaving Heater, Deg. F.	196	200
Feed Water Temperature—Leaving Economizer, Deg. F.	357	357
PreHeated Air Temperatures, Deg. F.	385	388
Stack Gas Temperature, Deg. F.	425	426
Gas Pressure at Boilers, inches water	7.8	8.3
Distribution of Blast Furnace Gas		
To Boilers, %	55.4	76.2
To Stoves, %	22.0	22.0
To Bleeders, by Diff.	22.6	1.8
	100	100

Distribution of Steam in B. H. P.—Including Auxiliaries

	Month January	Week Jan. 7-13
Generated—Blast Furnace Boilers	17,680	23,069
From Open Hearth Boilers	—179	+153
Total Steam Used at Station	17,501	23,222
To Electric Power	12,198	17,875
To Turbo-Blowers	5,069	5,077
To Blast Furnaces Direct	234	270
To Open Hearth	179	---
Total	17,680	23,222
Electric Power		
Average K. W. per Hr.—Generated (Net)	26,850	39,245
Average K. W. per Hr.—Auxiliaries	690	1,381
Average K. W. per Hr.—Total	27,540	40,625
Lbs. Steam per K. W. Hr.—Gross	12.44	12.60
Vacuum Inches of Hg.—Corrected to 30" Bar.		
No. 1 Generator	27.87	27.90
No. 2 Generator	27.67	27.75
A Turbo-Blower	27.77	27.43
B Turbo-Blower	27.59	27.68
C Turbo-Blower	27.75	---
Temperature of Atmosphere	50	43
Cooling Tower Temperatures:		
Entering Towers	87	90
Leaving Towers	72	72

FAIRFIELD POWER HOUSE
January 1929

To Electric Current:

Steam Used by Turbo-Generators	B. H. P. Mo.	10,681
Steam Used by Condenser Auxiliaries	B. H. P. Mo.	322
Steam Used by Other Auxiliaries	B. H. P. Mo.	1,141
Steam Lost in Piping	B. H. P. Mo.	54
Total	B. H. P. Mo.	12,196
Thousand K. W. Produced		20,575
Thousand K. W. Consumed by Auxiliaries		308.4
Thousand K. W. Consumed by Other Facilities		205.8
Thousand K. W. Net Production		20,060.8

Lbs. Steam per K. W. Hour Gross Production

Main Units	10.95
Total Including Auxiliaries	12.44

B. T. U.'s per K. W. Hour Gross Based on Steam

Consumed by Main Units	12,770
Consumed by Auxiliaries	383
Used for Miscellaneous Purposes	1,357
Lost in Piping	64
Total	14,574

B. T. U.'s per K. W. Hour Gross Based on Fuel

Consumed by Main Units	15,325
Consumed by Auxiliaries	463
Used for Miscellaneous Purposes	1,635
Lost in Piping	77
Total	17,500
Average Vacuum Ins. Hg. Corrected to 30" Bar.	27.77
Average Steam Pressure at Throttle, Lbs. Gauge	338
Average Steam Temperature at Throttle Deg. F.	642
Average Degrees Superheat	209
Lbs. Steam per B. H. P.	28.75

FAIRFIELD POWER HOUSE AND BOILER PLANT
January 1929

	Total Lbs. Month	Total B. H. P.	Avge. B. H. P. 744 Hrs.	Avge. B. H. P. 730 Hrs.	
Total Steam Generated	370,803,000	537,396	17,336	17,680	
To Open Hearth Department	3,763,000	5,454	176	179	
Used at Station	367,040,000	531,942	17,160	17,501	
To Blast Furnace Department					
Turbo-Blower Main Units	90,560,000	131,250		4,318	%
Turbo-Blower Condenser Auxiliaries	5,617,000	8,140		268	
Turbo-Blower Boiler Auxiliaries	9,578,000	13,880		458	
Blast Furnace Direct	4,920,000	7,130		234	
Blast Furnace Boiler Auxiliaries	525,000	760		25	
TOTAL	111,200,000	161,160	5,199	5,303	30.3%
To Electric Current					
Turbo-Generator Main Units	225,140,000	326,300		10,735	%
Turbo-Generator Condenser Auxiliaries	6,750,000	9,782		322	
Turbo-Generator Boiler Auxiliaries	23,950,000	34,700		1,141	
TOTAL	255,840,000	370,782	11,961	12,198	69.7%
TOTAL USED	367,040,000	531,942	17,160	17,501	100.0%

Blast Furnace Top Gas	Million B. T. U. Per Hour	Gross Tons Month	Gas Equiv. Day	Per Cent.
To Boilers	675.1	16,610	*535.80	55.4
To Stoves	268.1	6,595	212.74	22.0
To Bleeders	275.5	6,777	218.62	22.6
TOTAL	1,218.7	29,982	967.16	100.00
To Blowing	207.96	5,117	165.06	30.3
To Current	478.44	11,772	379.74	69.7
Total Used at Station	686.40	16,889	544.80	100.0
To Open Hearth	7.04	174	5.61	
TOTAL USED	693.44	17,063	550.41	
Blast Furnace Boilers				
From Blast Furnace Gas	675.10	16,610	535.80	97.4
From Coal	18.34	453	14.61	2.6
TOTAL USED	693.44	17,063	550.41	100.0

The Application of 300 Series Ball or Roller Bearings to Westinghouse Mill Type Sleeve Bearing Motors

By J. L. BROWN*

Considerable interest in the application of roller bearings to mill type motors has developed during the past few years. Many operators now specify roller bearings on new motors which they purchase from time to time for replacements or plant extensions; and also some operators have modified some existing sleeve bearing motors so that some sort of roller bearing mounting can be used.

It has been relatively simple to design new motors so as to readily accommodate a suitable size of practically all makes of roller bearings. However,

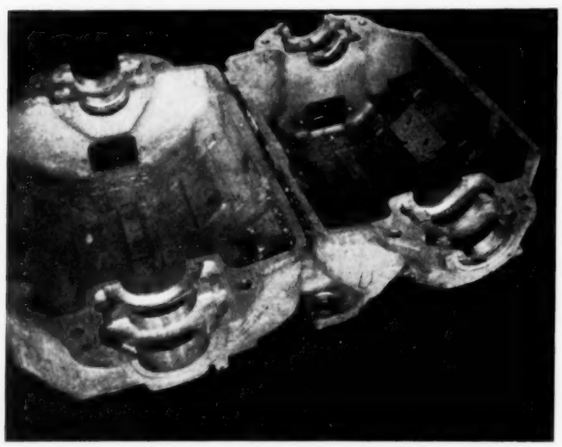


FIG. III.

the lack of uniformity in shape and width of the various types of roller bearings heretofore employed, has made complete interchangeability impossible. Interchangeability of armatures **complete with roller bearings and cartridges,** in frames designed for roller bearings, has been considered the maximum obtainable.

Recently, however, in co-operation with the various roller bearing manufacturers, and after two years of effort, complete interchangeability has been achieved in practically all Type MC roller bearing motor designs. Figure I.* shows bearing housings for a frame 60 or 70 MC mill motor, in which various different makes of roller bearings and standard double row ball bearings are mounted, and in which all principal dimensions are identical, so that the different bearing assemblies are completely interchangeable. The tabulations adjacent to the different views give the number designations of the bearings suitable for mill type MC motors from frame 20 to 103, and also show the principal dimensions of the bearing assembly. It is to be noted that the width, and inner and outer diameters of the bearing assembly are the same for all makes of bearings shown, so that the assemblies are completely interchangeable in new motors now being manufactured.

The problem of changing sleeve bearing MC motors into roller bearing motors, on the other hand, has been rather difficult. The actual change-overs present a miscellaneous assortment of non-interchangeable methods as regards both bearing dimensions and fit of the bearing cartridge in the motor frames. The evil effects of this lack of uniformity are readily apparent. In certain cases the type of roller bearing employed was not suitable for the service to which the motor was subsequently applied, but due to the dissimilar methods of mounting the different types of bearings, it was impossible to replace the unsuitable bearing with a type better adapted to the application. This condition arose not

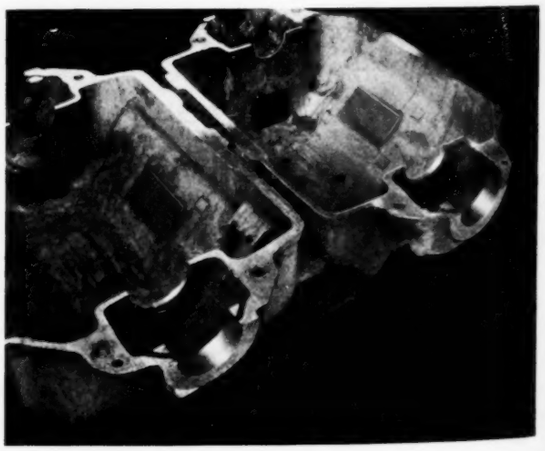


FIG. IV.

only because the two types were not interchangeable as to dimensions, thus requiring a new cartridge, but because the special machining of the frame to suit the first cartridge was unsuitable for a cartridge which would properly mount the second type of bearing. Figure II. shows several methods of mounting different types of roller bearings in old sleeve bearing motors, and illustrates the non-uniform methods which have been used in making changeovers.

Furthermore, armatures (complete with bearings and cartridges) for these special change-over jobs are not interchangeable with similar armatures for new roller bearing motors, with bearing mountings

*Mechanical Engineer, Motor Engineering Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

LIST OF ILLUSTRATIONS

DESCRIPTION

FIG. 1—Standard roller bearing assemblies for MC mill motors, frames 20 to 103.

FIG. 2—Miscellaneous non-interchangeable roller bearing assemblies.

FIG. 3—Photograph of MC-50 motor frame with housing machined for standard sleeve bearings. See preceding pages of text for figure.

FIG. 4—Photograph of same frame as shown by Figure 3 with center supporting web and other projections removed to prevent interference with roller bearing cartridge. See preceding pages of text for figure.

FIG. 5—Photograph of same frame as shown by Figure 4 with addition of metal for support of roller bearing. See preceding pages of text for figure.

FIG. 6—Photograph of same frame as shown by Figure 5 machined for standard roller bearing cartridge. See preceding pages of text for figure.

FIG. 7—Detail drawing of MC-50 sleeve bearing motor frame.

FIG. 8—Detail drawing of MC-50 frame showing material to be removed to accommodate roller bearings.

FIG. 9—Detail drawing of MC-50 frame showing material to be added to provide support for roller bearings.

FIG. 10—Detail drawing showing dimensions for machining MC-50 frame for standard roller bearings.

FIG. 11—Drawing showing standard roller bearing assembled in modified MC-50 frame.

FIG. 12—Drawing showing machining of shaft and spacer sleeves to adapt standard roller bearings to MC-50 sleeve bearing motor.

FIG. 13—Drawing showing machining of shaft and spacer sleeves to adapt standard roller bearings to sleeve bearing motors, frame sizes MC-20 to MC-103 inclusive.

FIG. 14—Drawing showing modifications to be made on MC-20 sleeve bearing motor frame for standard roller bearings.

FIG. 15—Drawing showing modifications to be made on MC-30 sleeve bearing motor frame for standard roller bearings.

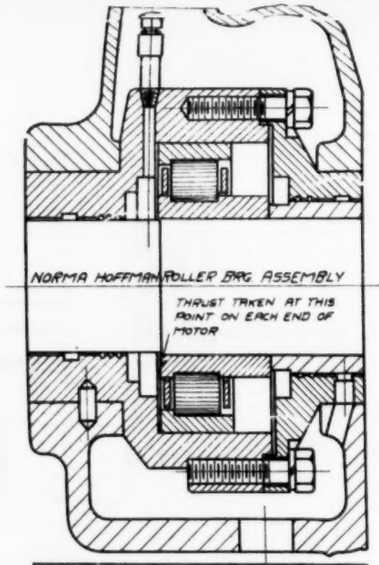
FIG. 16—Drawing showing modifications to be made on MC-40 and MC-50 sleeve bearings motor frame for standard roller bearings.

FIG. 17—Drawing showing modifications to be made on MC-60 and MC-70 sleeve bearing motor frames for standard roller bearings.

FIG. 18—Drawing showing modifications to be made on MC-80 sleeve bearing motor frame for standard roller bearings.

FIG. 19—Drawing showing modifications to be made on MC-90 sleeve bearing motor frame for standard roller bearings.

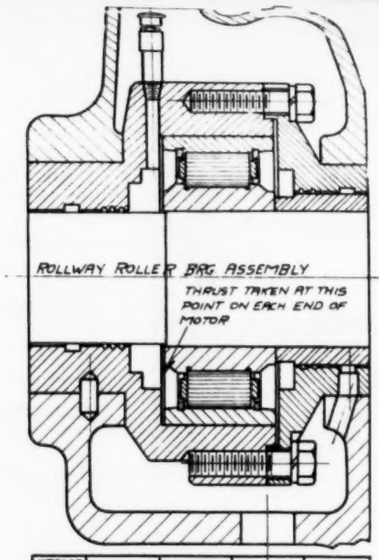
FIG. 20—Drawing showing modifications to be made on MC-100 and MC-103 sleeve bearing motor frame for standard roller bearings.



NORMA HOFFMAN ROLLER BRG ASSEMBLY

THRUST TAKEN AT THIS POINT ON EACH END OF MOTOR

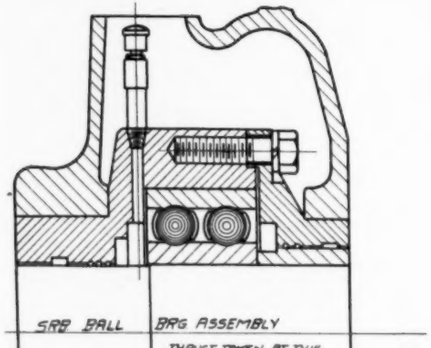
FRAME SIZE	BRG NO.	INSIDE DIA.	OUTSIDE DIA.	WIDTH
20	WIR 350L	1.3685	4.3307	1.750
30	WIR 365L	2.5591	5.5118	2.3125
40	WIR 375L	2.9528	6.2992	2.6875
50	WIR 375L	2.9528	6.2992	2.6875
60	WIR 395L	3.7402	7.8740	3.0625
70	WIR 395L	3.7402	7.8740	3.0625
80	WIR 410L	4.3307	9.4488	3.6250
90	WIR 420L	4.7244	10.2362	4.1250
100	WIR 430L	5.1181	11.0236	4.375
103	WIR 430L	5.1181	11.0236	4.375



ROLLWAY ROLLER BRG ASSEMBLY

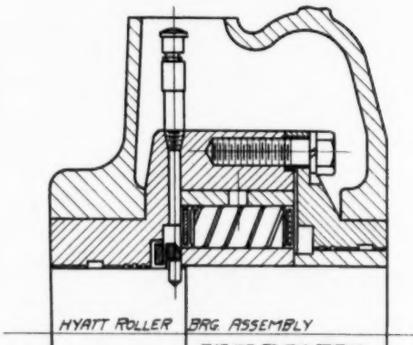
THRUST TAKEN AT THIS POINT ON EACH END OF MOTOR

FRAME SIZE	BRG NO.	INSIDE DIA.	OUTSIDE DIA.	WIDTH
20	MS 5310	1.3685	4.3307	1.750
30	MS 5313	2.5591	5.5118	2.3125
40	MS 5315	2.9528	6.2992	2.6875
50	MS5315	2.9528	6.2992	2.6875
60	MS5319	3.7402	7.8740	3.0625
70	MS 5319	3.7402	7.8740	3.0625
80	MS5322	4.3307	9.4488	3.6250
90	MS5324	4.7244	10.2362	4.1250
100	MS5326	5.1181	11.0236	4.3750
103	MS5326	5.1181	11.0236	4.3750



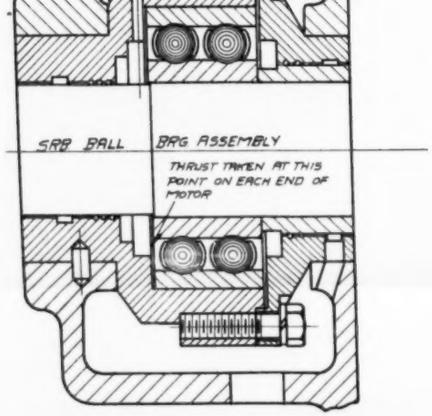
SRB BALL BRG ASSEMBLY

THRUST TAKEN AT THIS POINT ON EACH END OF MOTOR

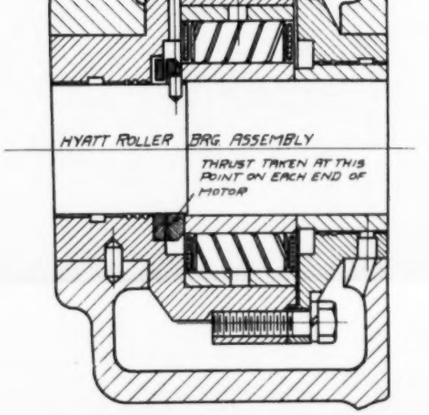


HYATT ROLLER BRG ASSEMBLY

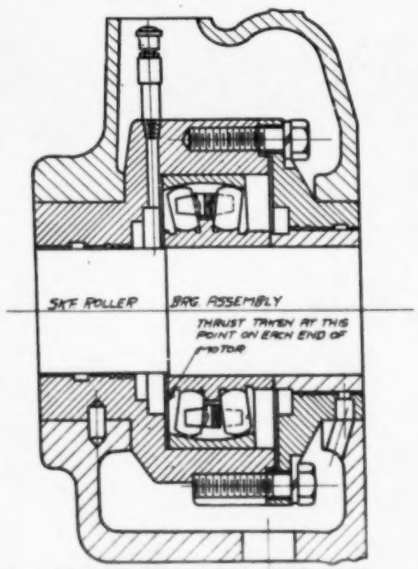
THRUST TAKEN AT THIS POINT ON EACH END OF MOTOR



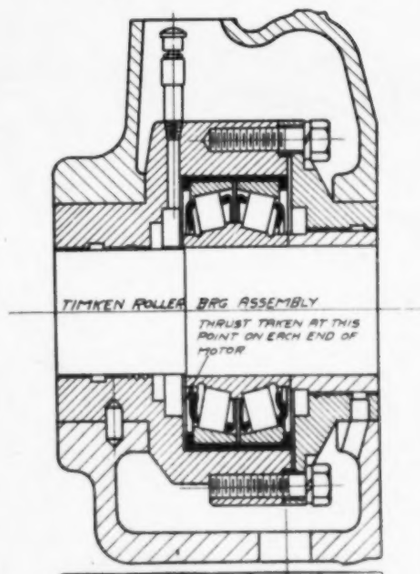
FRAME SIZE	BRG NO	INSIDE DIA	OUTSIDE DIA	WIDTH
20	5310	1.9685	4.3307	1.750
30	5313	2.5591	5.5118	2.3125
40	5315	2.9528	6.2992	2.6875
50	5315	2.9528	6.2992	2.6875
60	5319	3.7402	7.8740	3.0625
70	5319	3.7402	7.8740	3.0625
80	5322	4.3307	9.4488	3.6250
90				
100				
103				



FRAME SIZE	BRG. NO	INSIDE DIA	OUTSIDE DIA	WIDTH
20	310	1.9685	4.3307	1.750
30	M313	2.5591	5.5118	2.3125
40	M315	2.9532	6.2989	2.6875
50	M315	2.9532	6.2989	2.6875
60	319	3.7408	7.8736	3.1250
70	319	3.7408	7.8736	3.1250
80	322	4.3307	9.4488	3.7500
90	324	4.7244	10.2362	4.1250
100	326	5.1181	11.0236	4.3750
103	326	5.1181	11.0236	4.3750



FRAME SIZE	BRG NO	INSIDE DIA	OUTSIDE DIA	WIDTH
20	52310	1.9685	4.3307	1.750
30	52313	2.5591	5.5118	2.3125
40	52315	2.9528	6.2992	2.6875
50	52315	2.9528	6.2992	2.6875
60	52319	3.7402	7.8740	3.0625
70	52319	3.7402	7.8740	3.0625
80	52322	4.3307	9.4488	3.6250
90	52324	4.7244	10.2362	4.1250
100	52326	5.1181	11.0236	4.3750
103	52326	5.1181	11.0236	4.3750



FRAME SIZE	BRG NO	INSIDE DIA	OUTSIDE DIA	WIDTH
20	8310	1.9685	4.3307	1.750
30	8313	2.5591	5.5118	2.3125
40	8315	2.9528	6.2992	2.6875
50	8315	2.9528	6.2992	2.6875
60	8319	3.7402	7.8740	3.0625
70	8319	3.7402	7.8740	3.0625
80	8322	4.3307	9.4488	3.6250
90	8324	4.7244	10.2362	4.1250
100	8326	5.1181	11.0236	4.3750
103	8326	5.1181	11.0236	4.3750

FIG. 1

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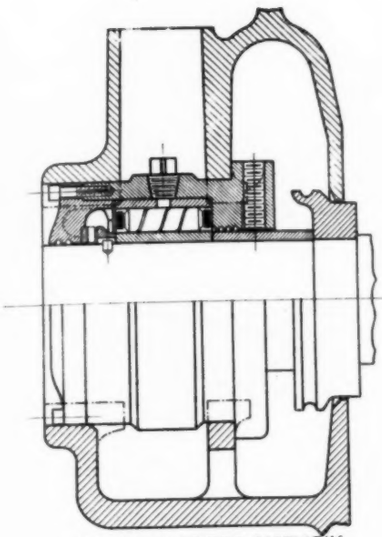
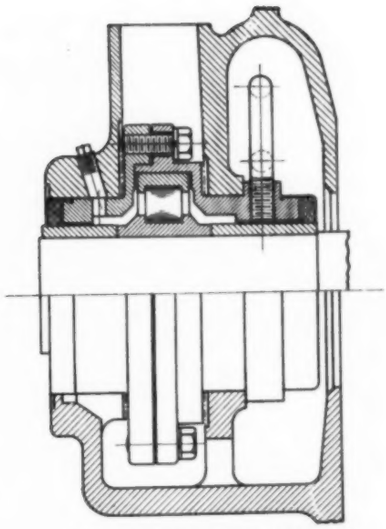
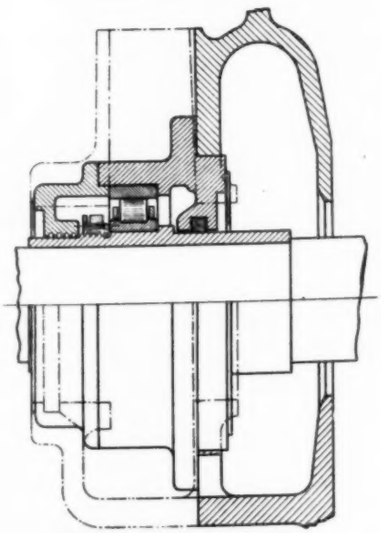


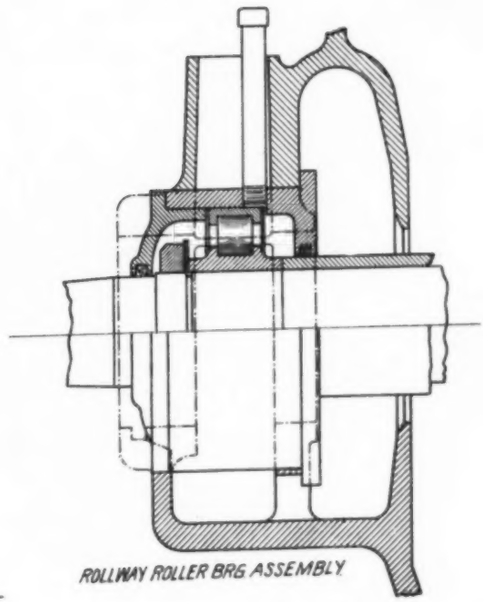
HYATT ROLLER BRG. ASSEMBLY



ROLLWAY ROLLER BRG. ASSEMBLY



NORMA HOFFMANN ROLLER BRG. ASSEMBLY



ROLLWAY ROLLER BRG. ASSEMBLY

FIG. II

VIEW SHOWING HOW MUCH MATERIAL MUST BE REMOVED IN MODIFYING

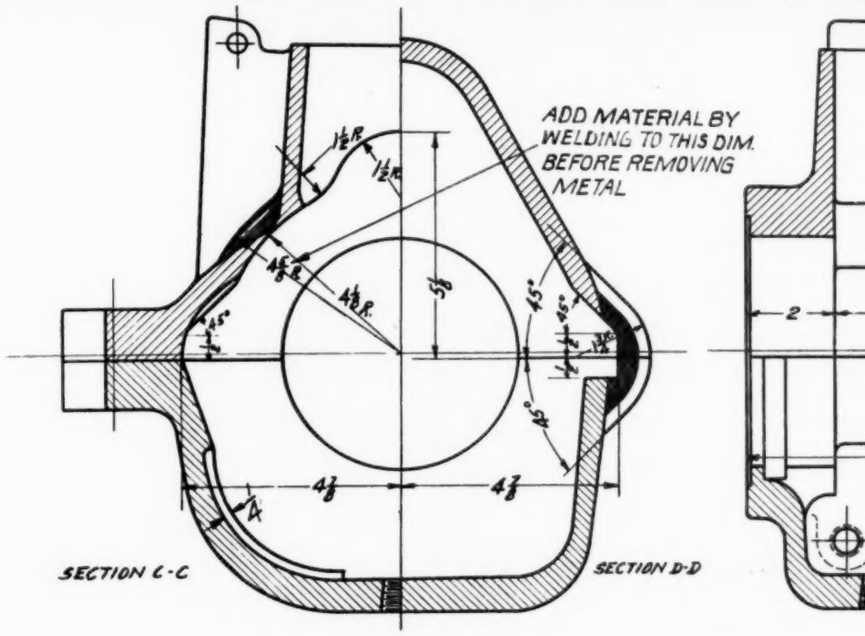


FIG. VIII

VIEW SHOWING HOW MUCH MATERIAL MUST BE ADDED BY WELDING IN BEARING HOUSING OF 50 MC MOTOR FRAME IN PREPARING IT FOR ROLLER BEARING CARTRIDGE

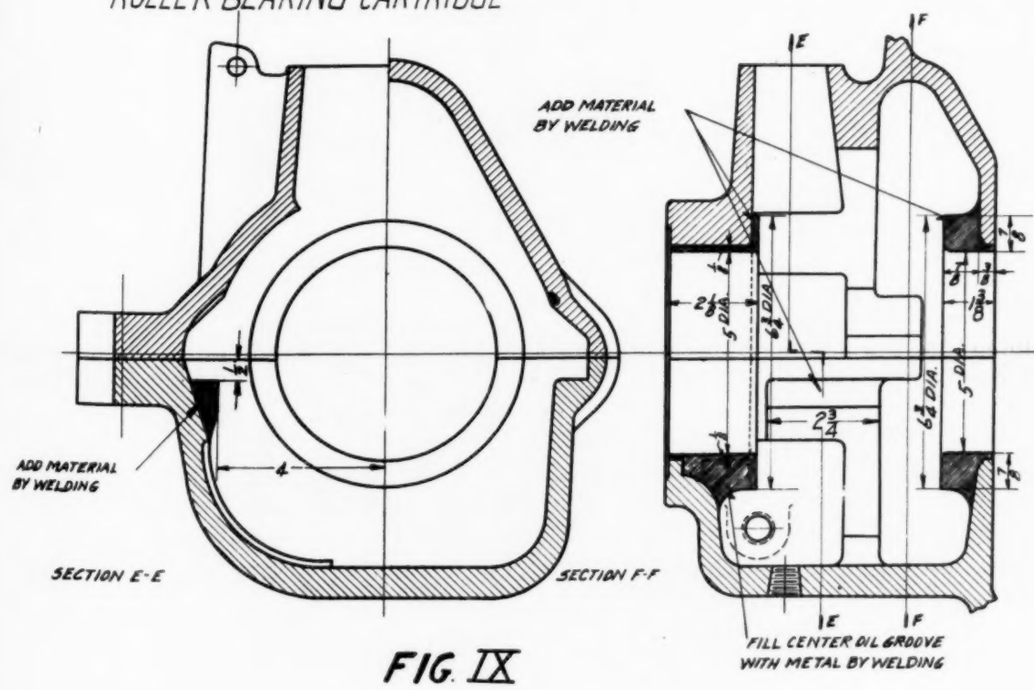
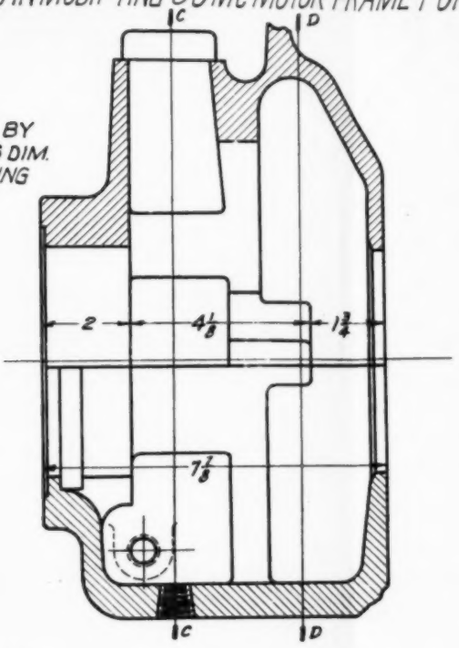
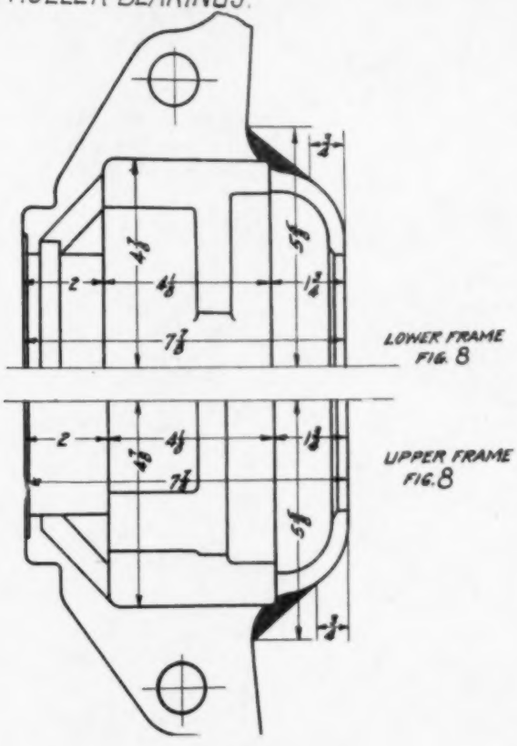


FIG. IX

D IN MODIFYING 50 MC MOTOR FRAME FOR MOUNTING ROLLER BEARINGS.



VII



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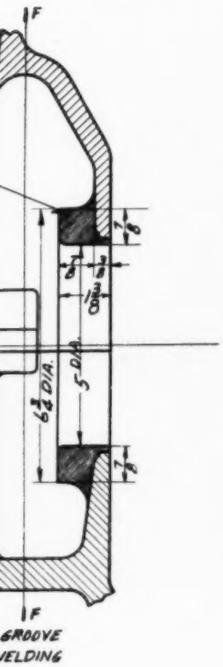


HOUSING OF 50 "MC" MOTOR FRAME ARRANGED FOR SLEEVE BEARINGS

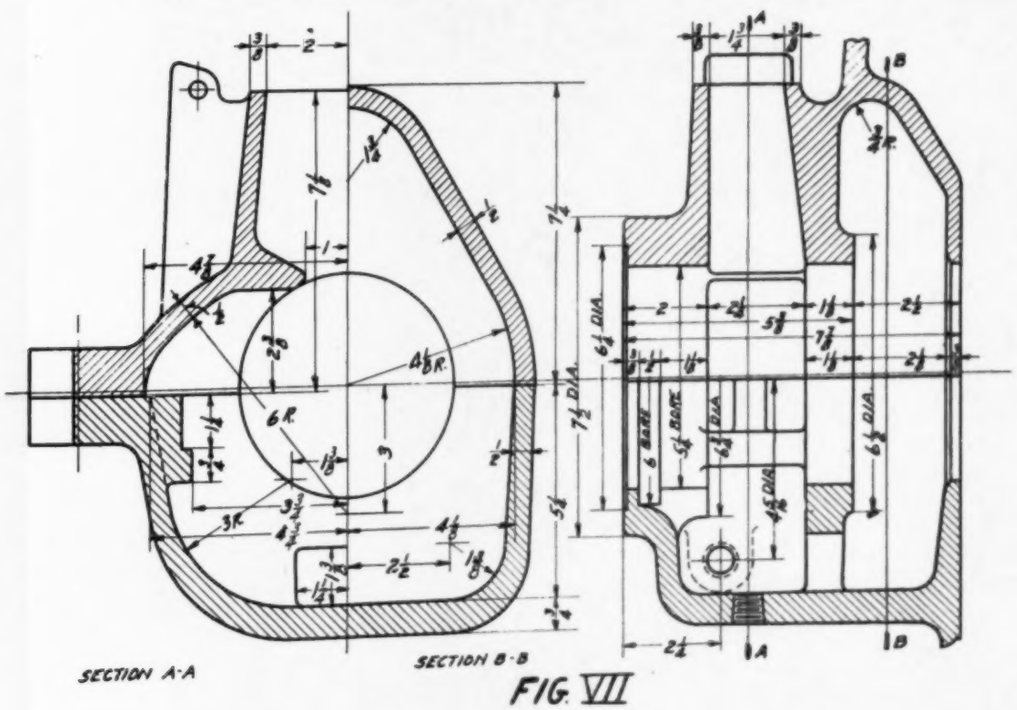


FIG. VII

VIEW SHOWING MACHINING DIMENSIONS TO AC

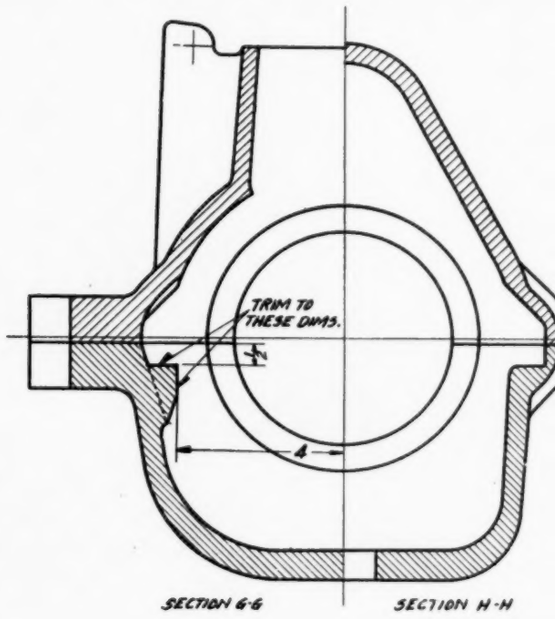


FIG. X

VIEW SHOWING ROLLER BEARING ASSEMBLED IN 50 MC FRAME

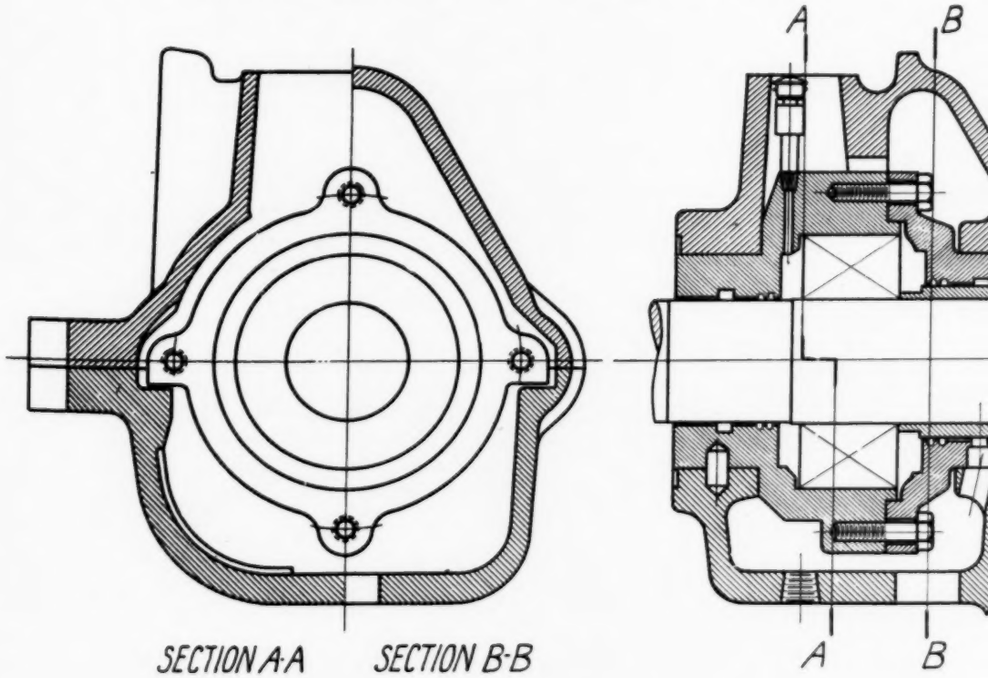


FIG. XI

NSIONS TO ACCOMODATE ROLLER BEARING CARTRIDGE

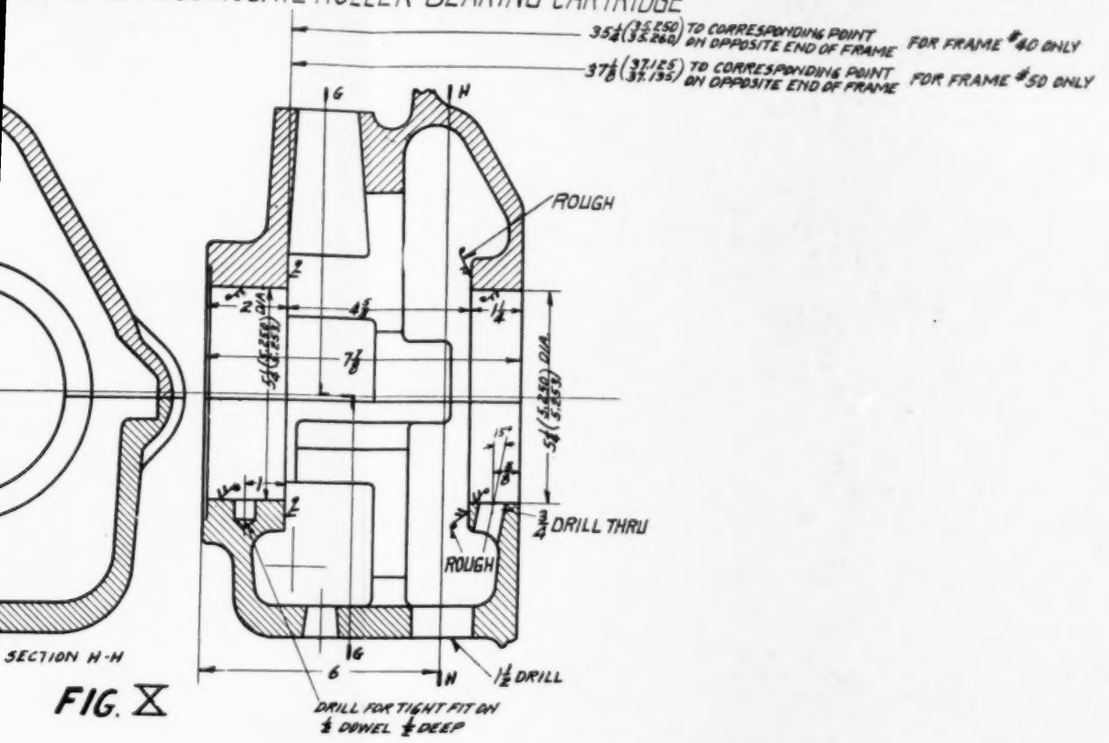
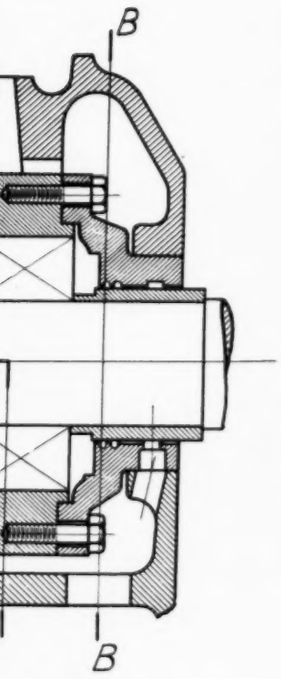

35¼ (35.250 / 35.264) TO CORRESPONDING POINT ON OPPOSITE END OF FRAME FOR FRAME #40 ONLY
37⅛ (37.125 / 37.139) TO CORRESPONDING POINT ON OPPOSITE END OF FRAME FOR FRAME #50 ONLY
ROUGH
¾ DRILL THRU
ROUGH
SECTION H-H
1½ DRILL
DRILL FOR TIGHT FIT ON ½ DOWEL ½ DEEP

FIG. X

RAME



MOTOR D.C. FRAME #50 TYPE MC
SHAFT MACHINING

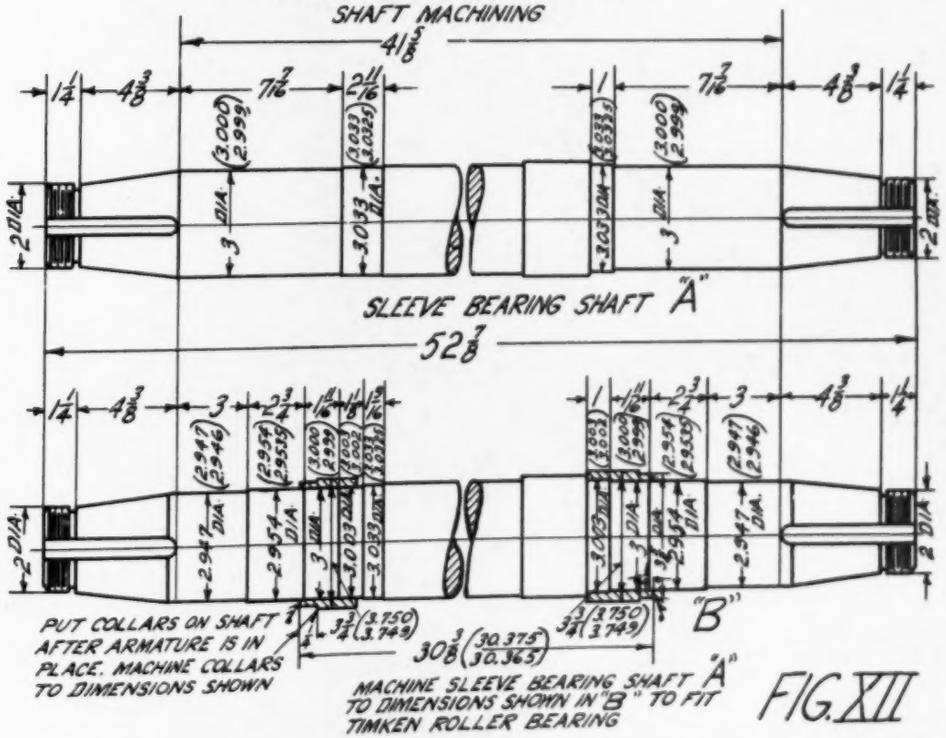

SLEEVE BEARING SHAFT "A"
"B"
PUT COLLARS ON SHAFT AFTER ARMATURE IS IN PLACE. MACHINE COLLARS TO DIMENSIONS SHOWN
MACHINE SLEEVE BEARING SHAFT "A" TO DIMENSIONS SHOWN IN "B" TO FIT TIMKEN ROLLER BEARING

FIG. XII

20 MC
30 MC
40 MC
50 MC

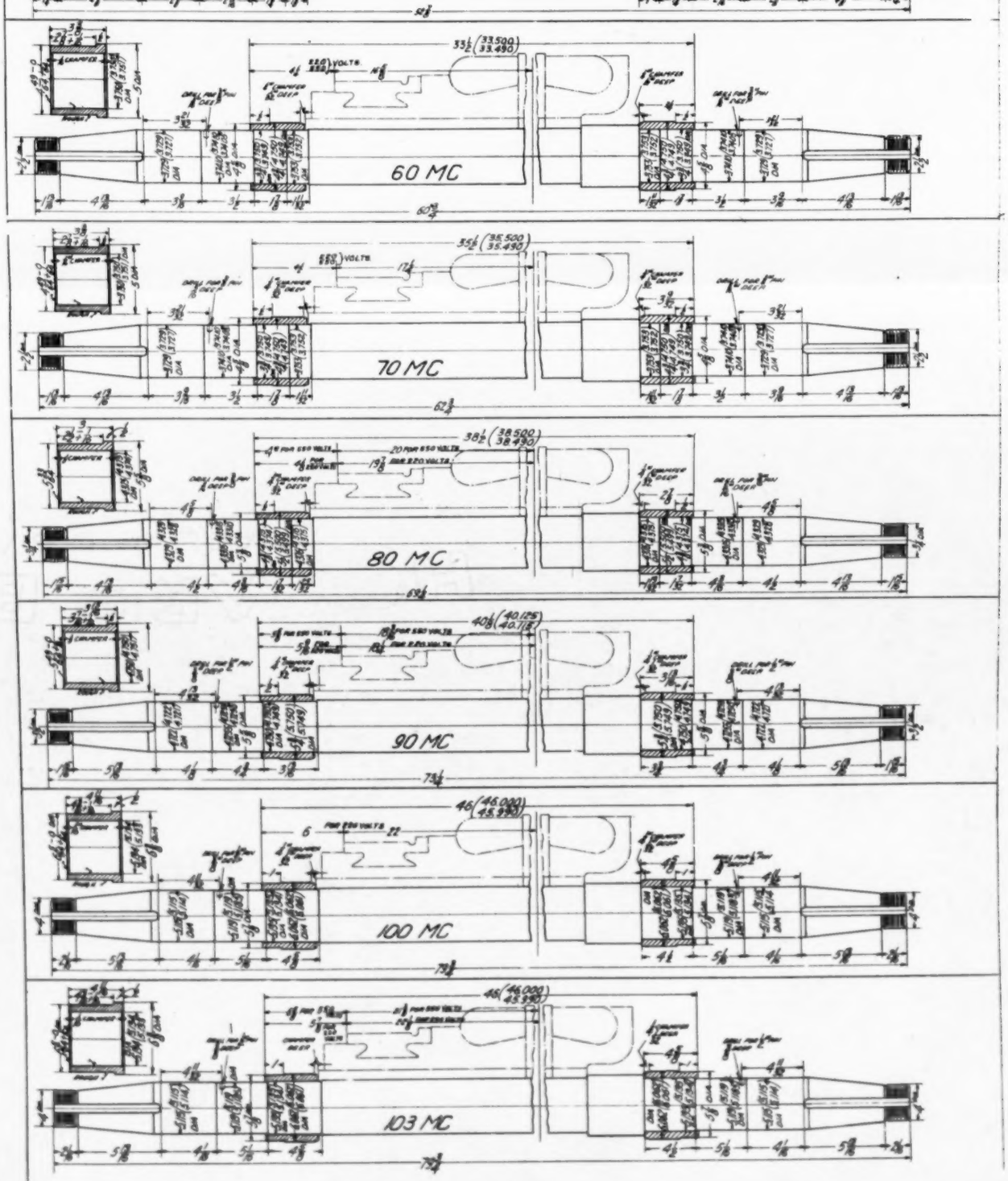


FIG XIII

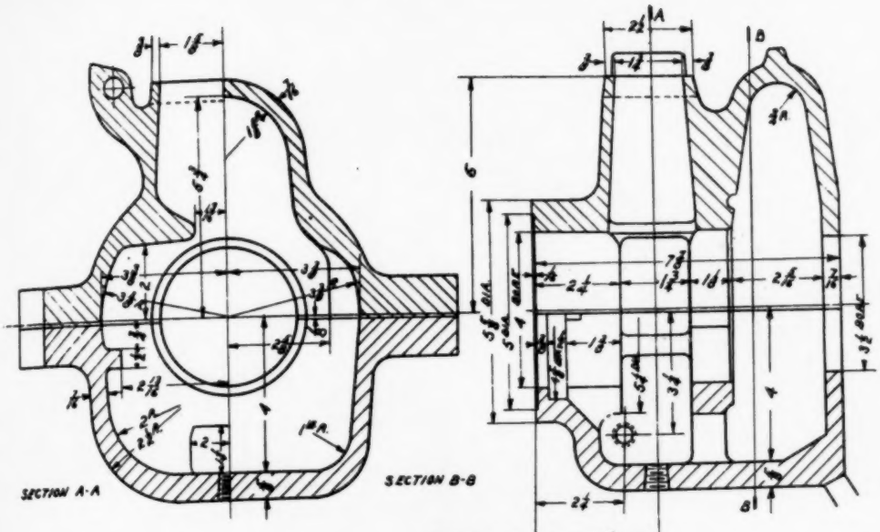


FIG. 1

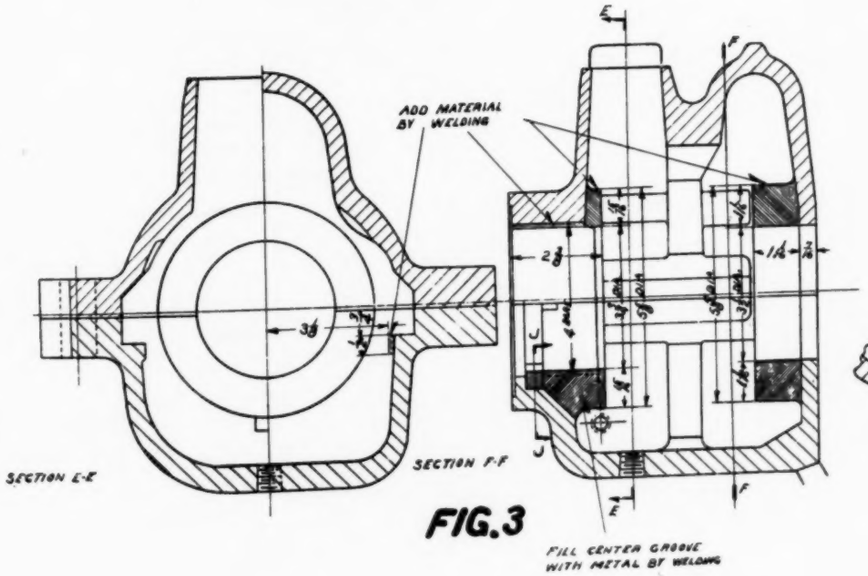


FIG. 3

FILL CENTER GROOVE WITH METAL BY WELDING

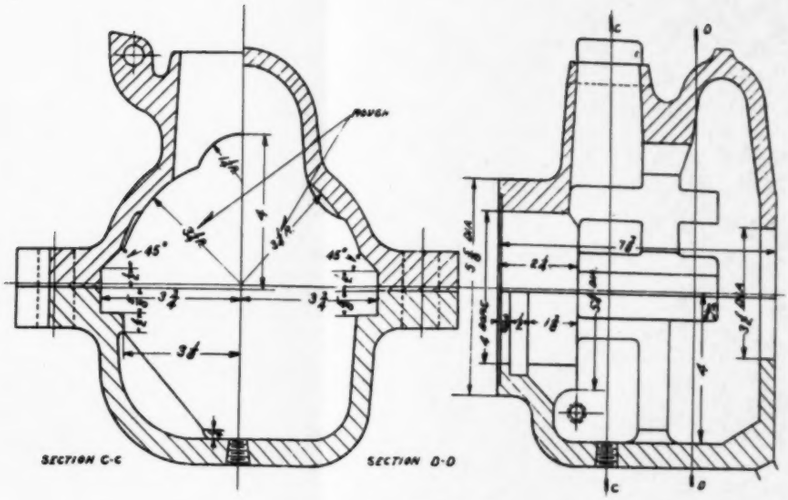
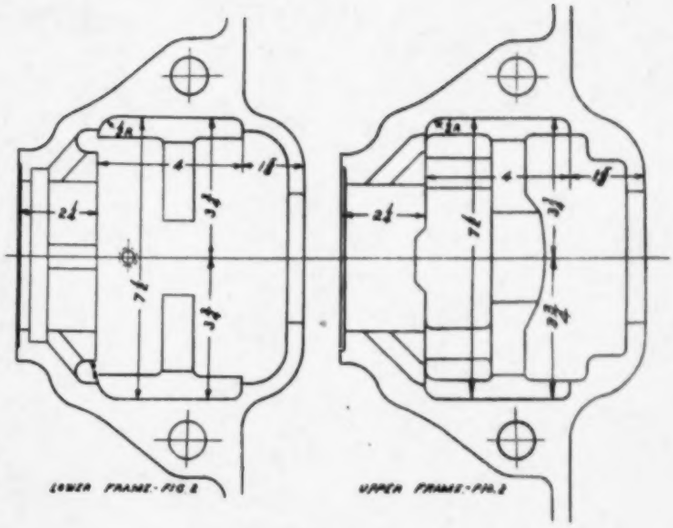


FIG.2



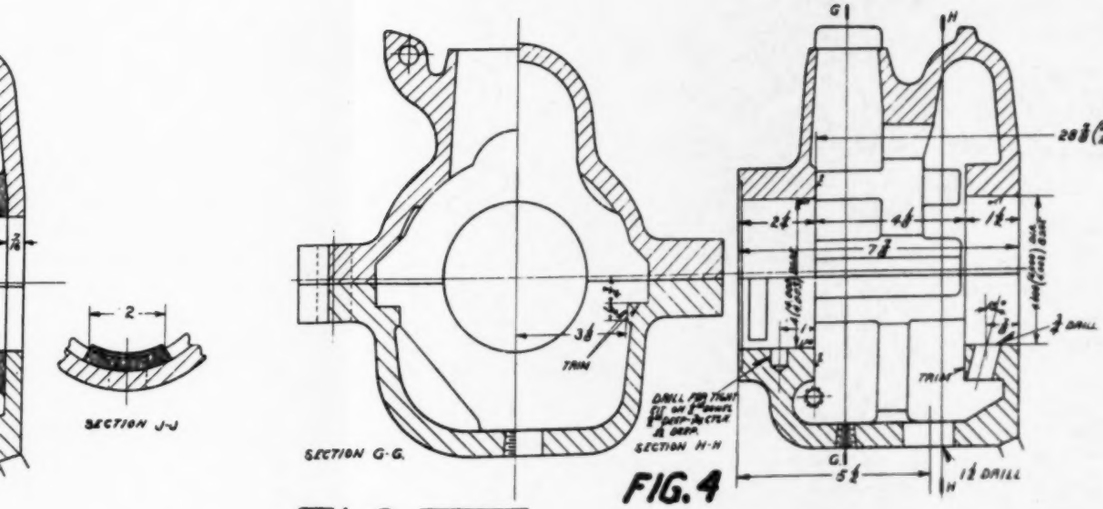


FIG. 4

FIG. XIV

FIG 1 SHOWS HOUSING FOR SLEEVE BRG
FIG. 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED
FIG 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING
FIG 4 GIVES MACHINING DIMENSIONS

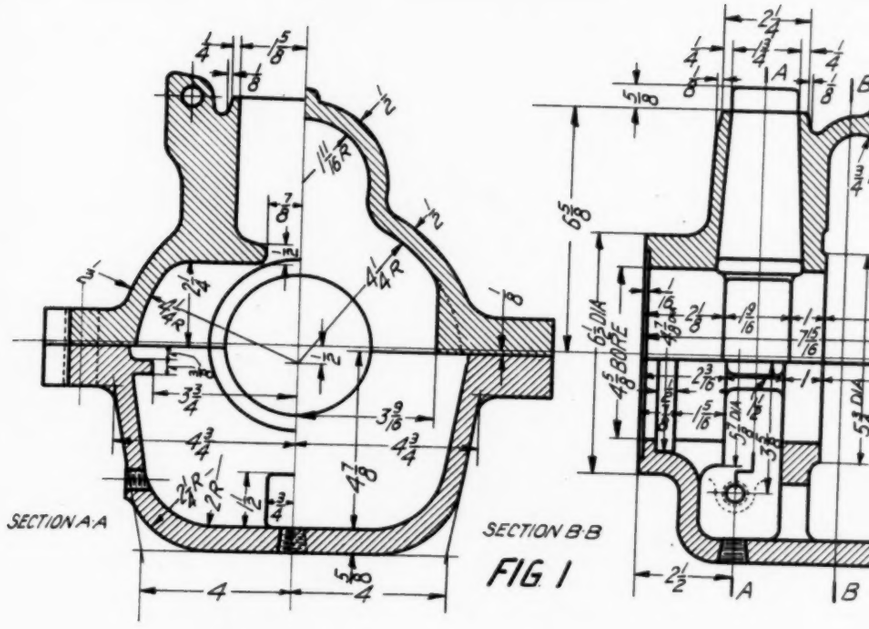

SECTION A-A
SECTION B-B

FIG 1

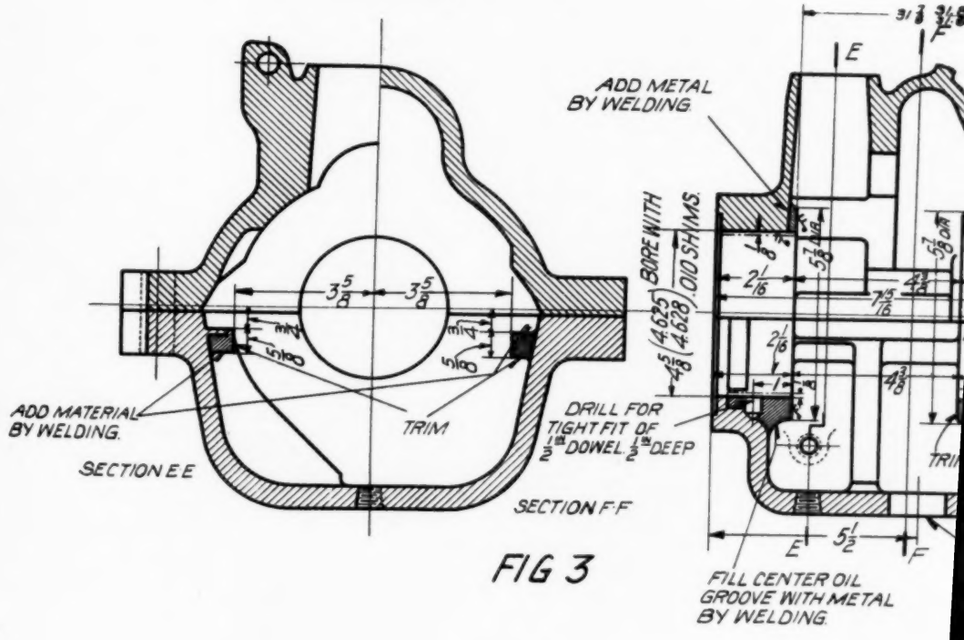
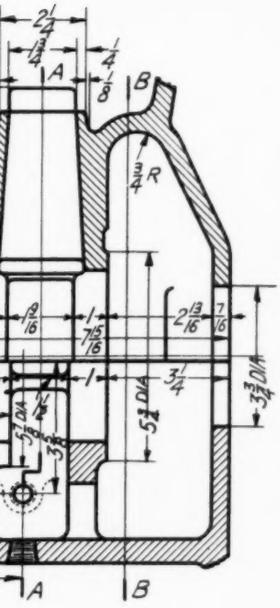
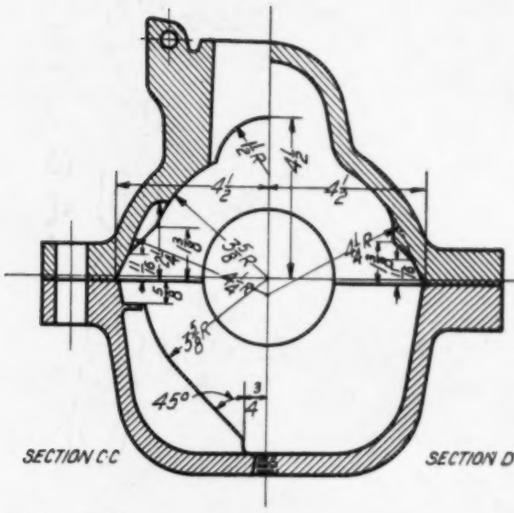

ADD MATERIAL BY WELDING.
TRIM
SECTION E-E
ADD METAL BY WELDING.
DRILL FOR TIGHT FIT OF 1/2" DOWEL 1/2" DEEP
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING.

FIG 3





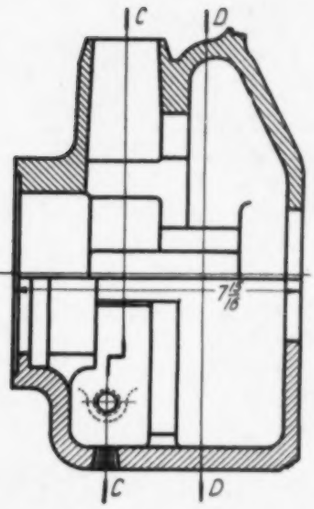
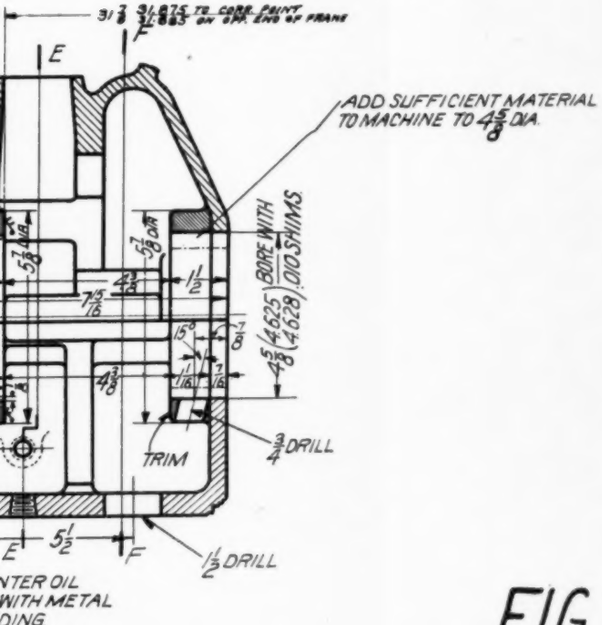
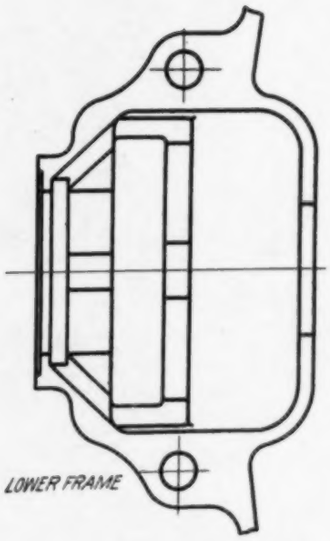


FIG 1 SHOWS HOUSING FOR SLEEVE BEARING.
FIG 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED.
FIG 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING AND GIVES MACHINING DIMENSIONS.

FIG 2





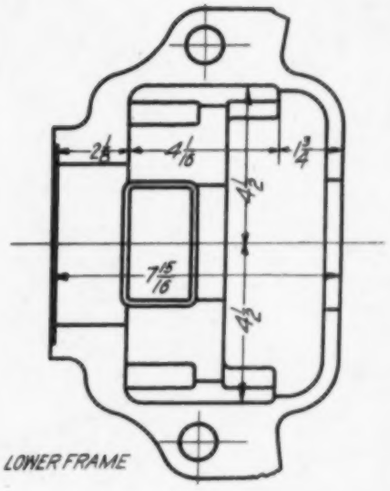


FIG. XV

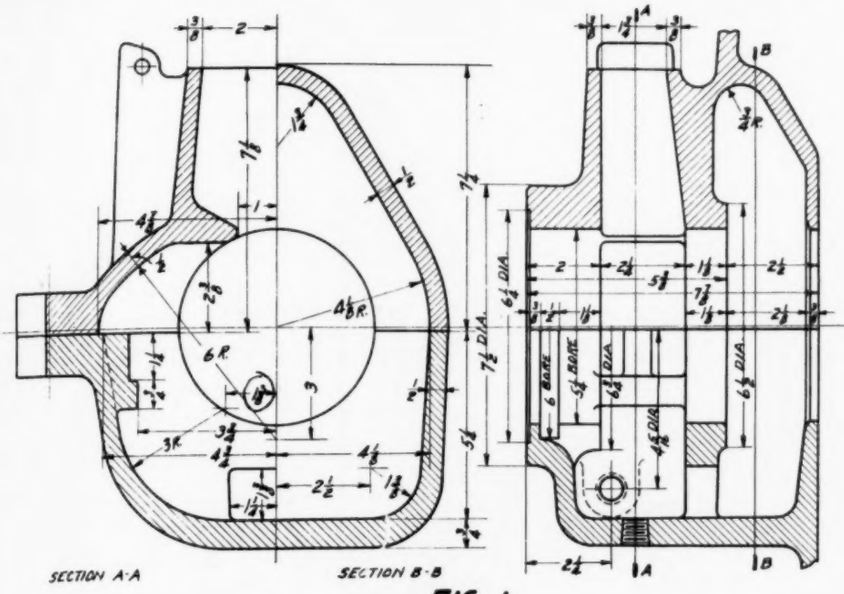

SECTION A-A
SECTION B-B
SECTION C-C

FIG. 1

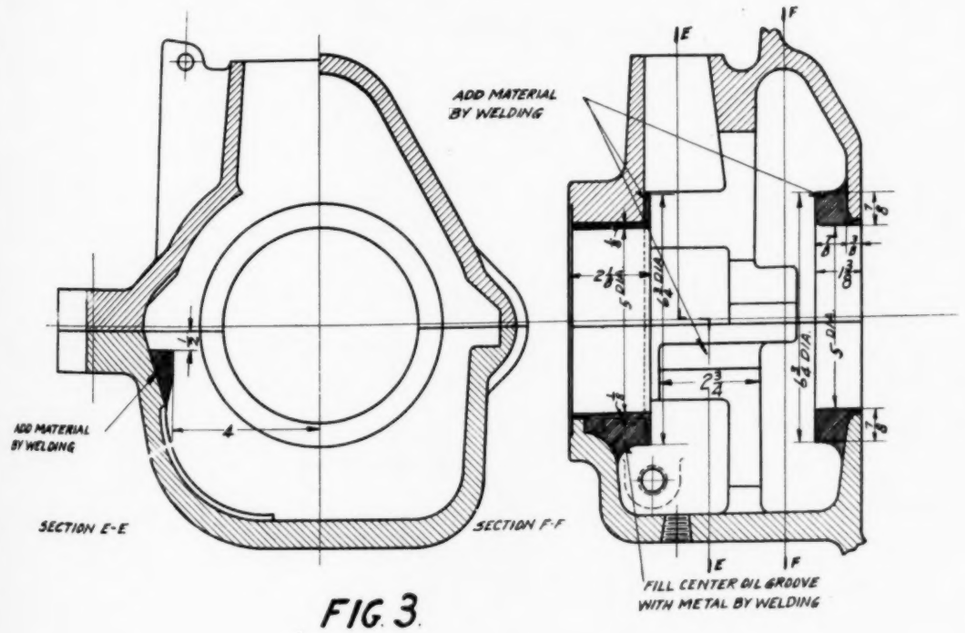

ADD MATERIAL BY WELDING
ADD MATERIAL BY WELDING
SECTION E-E
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING

FIG. 3

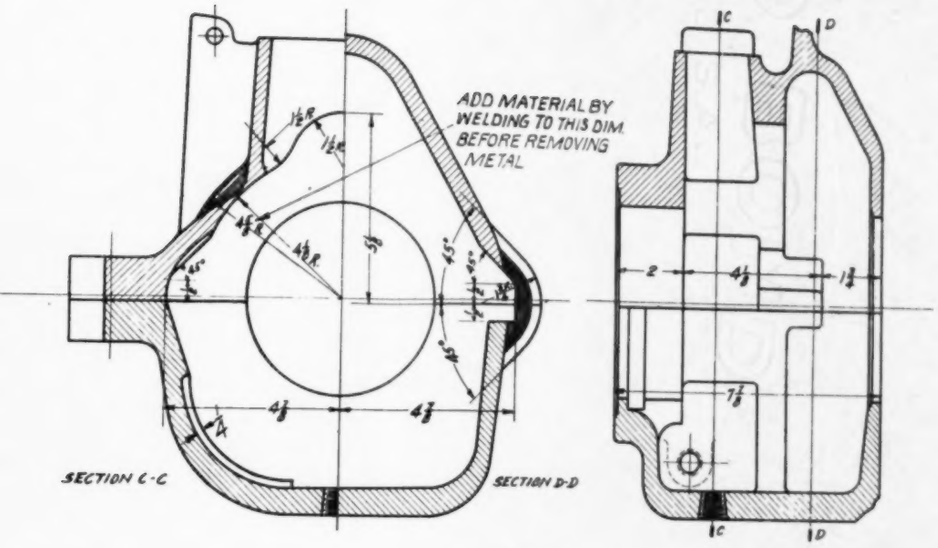
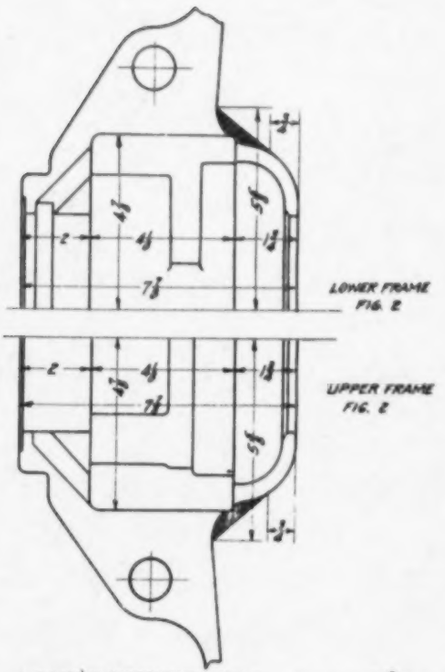


FIG. 2



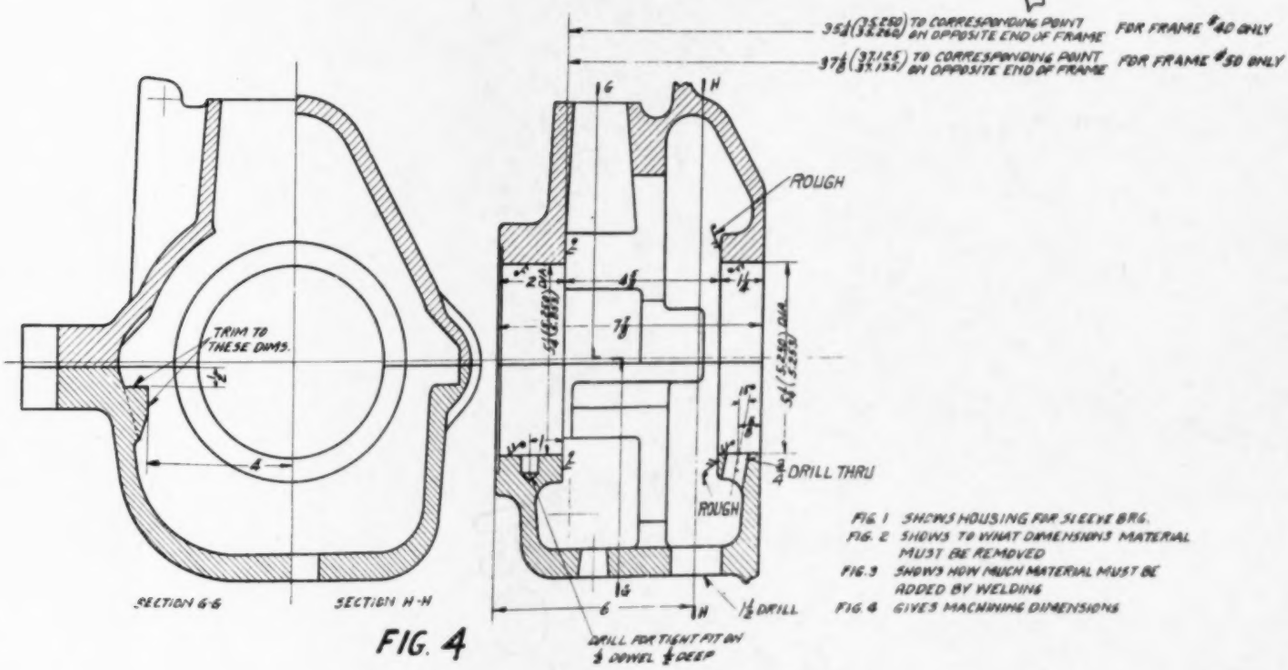
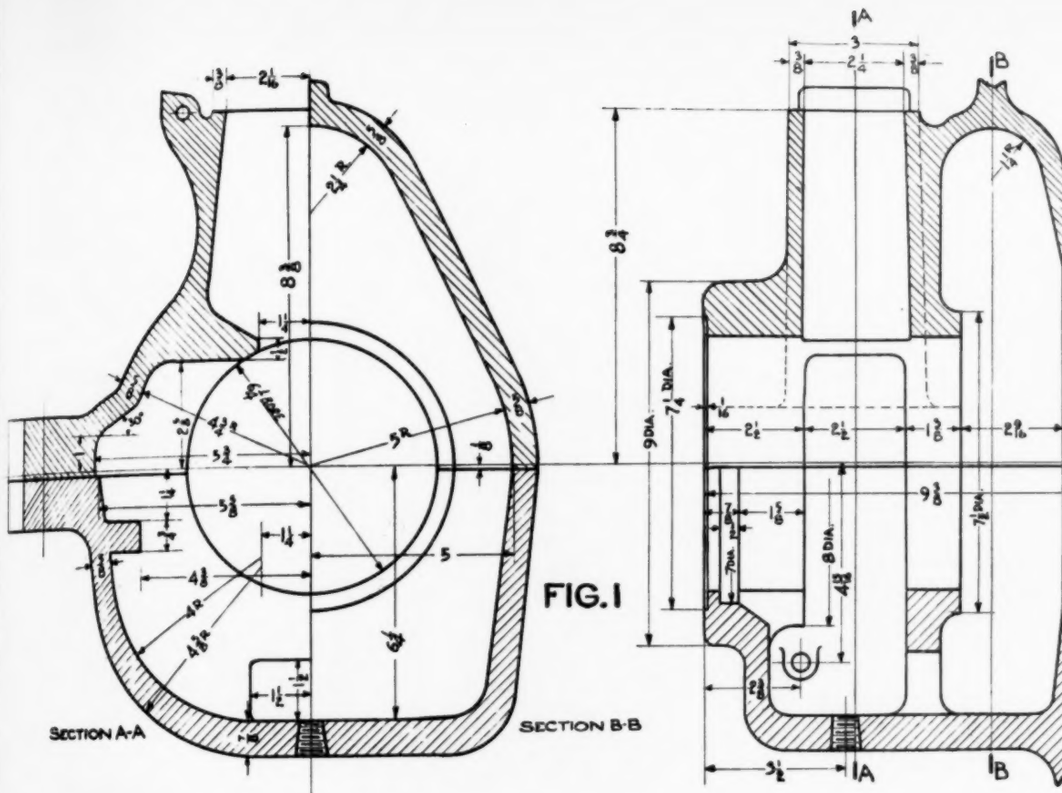


FIG. 4

FIG. 1 SHOWS HOUSING FOR SLEEVE BRG.
FIG. 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED
FIG. 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING
FIG. 4 GIVES MACHINING DIMENSIONS

FIG XVI


SECTION A-A
SECTION B-B
1A
1B
FIG. 1

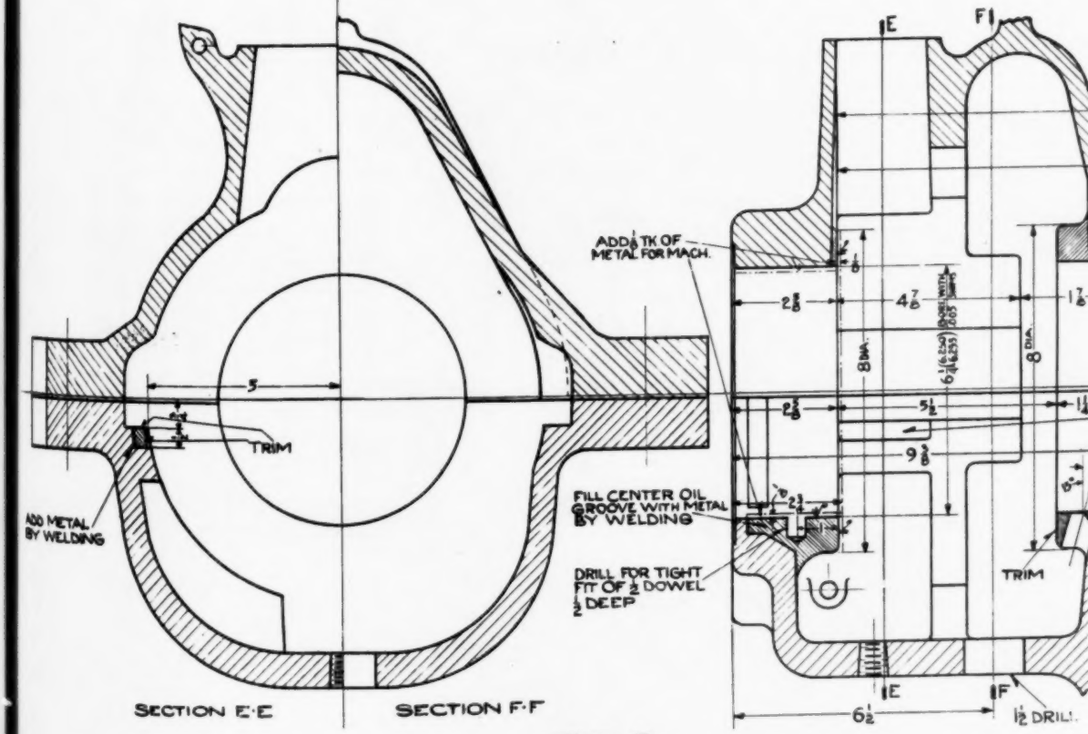
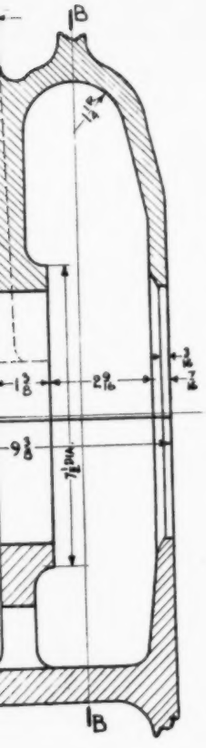
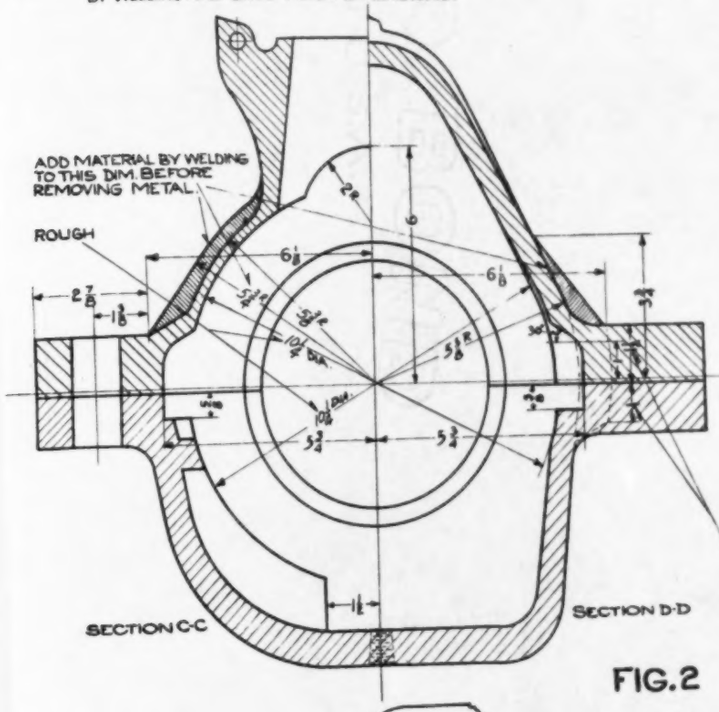

SECTION E-E
SECTION F-F
ADD METAL BY WELDING
TRIM
ADD 1/8 TK OF METAL FOR MACH.
FILL CENTER OIL GROOVE WITH METAL BY WELDING
DRILL FOR TIGHT FIT OF 1/2 DOWEL 1/2 DEEP
1E
1F
TRIM

FIG. 3

FIG. 1 SHOWS HOUSING FOR SLEEVE BEARING
FIG. 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED.
FIG. 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING AND GIVES MACH. DIMENSIONS.





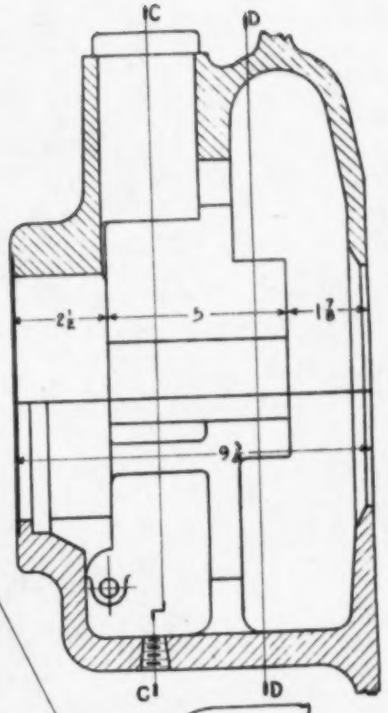
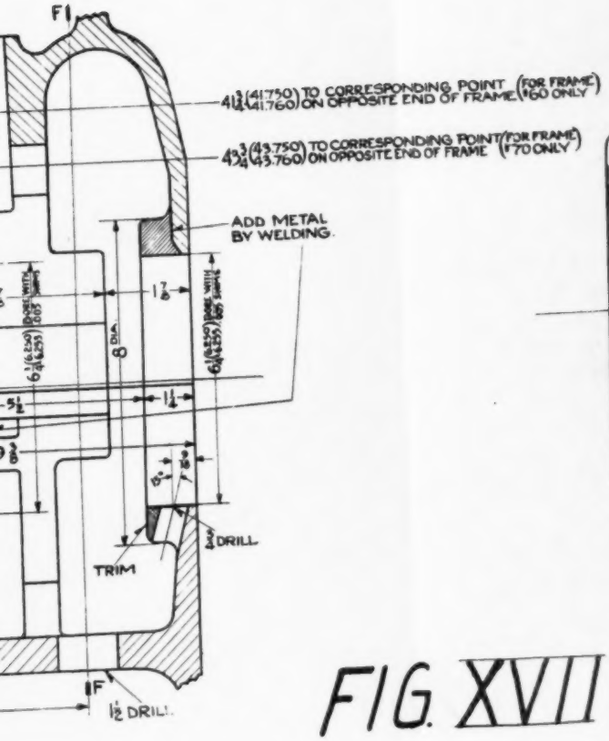


FIG. 2


F
4 1/2 (41.750) TO CORRESPONDING POINT (FOR FRAME 160) ON OPPOSITE END OF FRAME. (160 ONLY)
4 3/4 (43.750) TO CORRESPONDING POINT (FOR FRAME 170) ON OPPOSITE END OF FRAME (170 ONLY)
ADD METAL BY WELDING.
TRIM
DRILL
F
1/2 DRILL

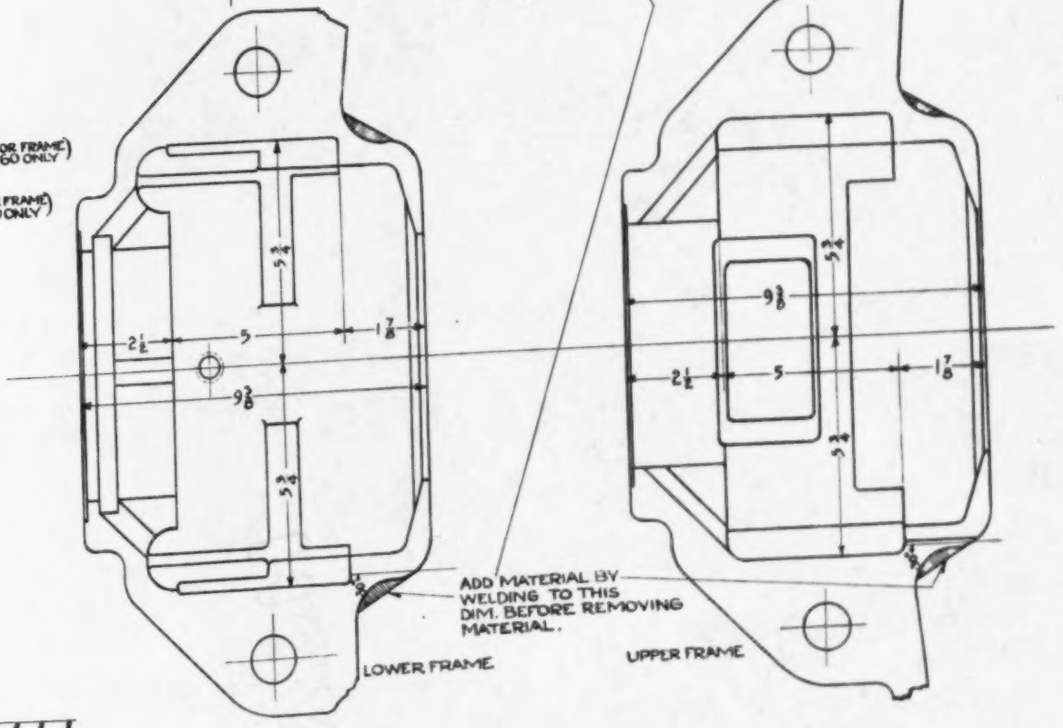


FIG. XVII

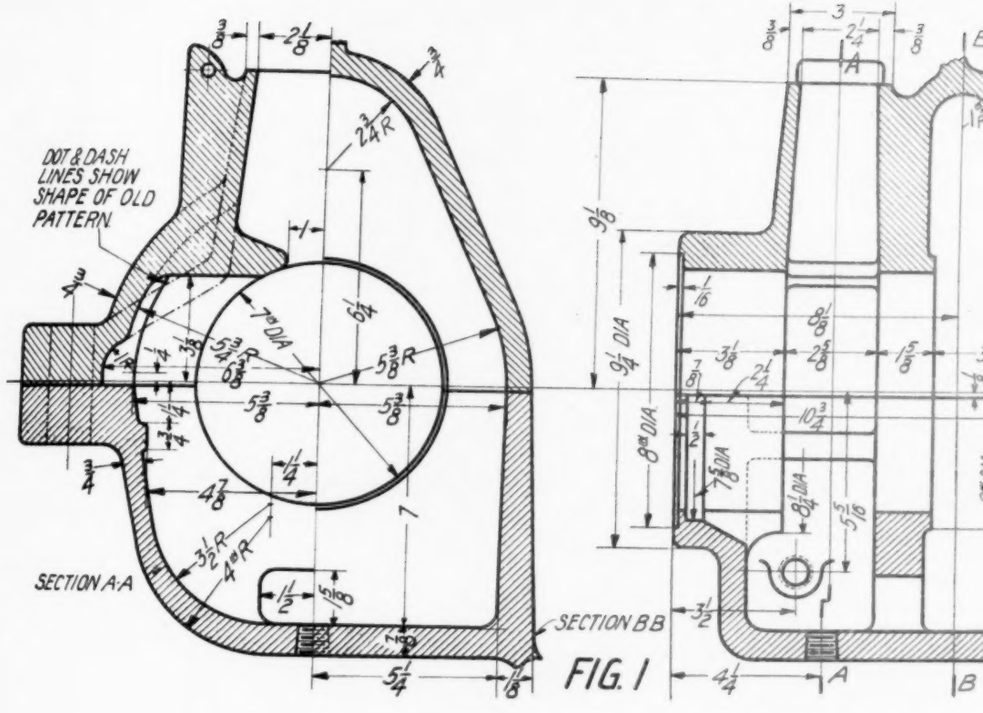

DOT & DASH LINES SHOW SHAPE OF OLD PATTERN.
SECTION A-A
SECTION B-B

FIG. 1

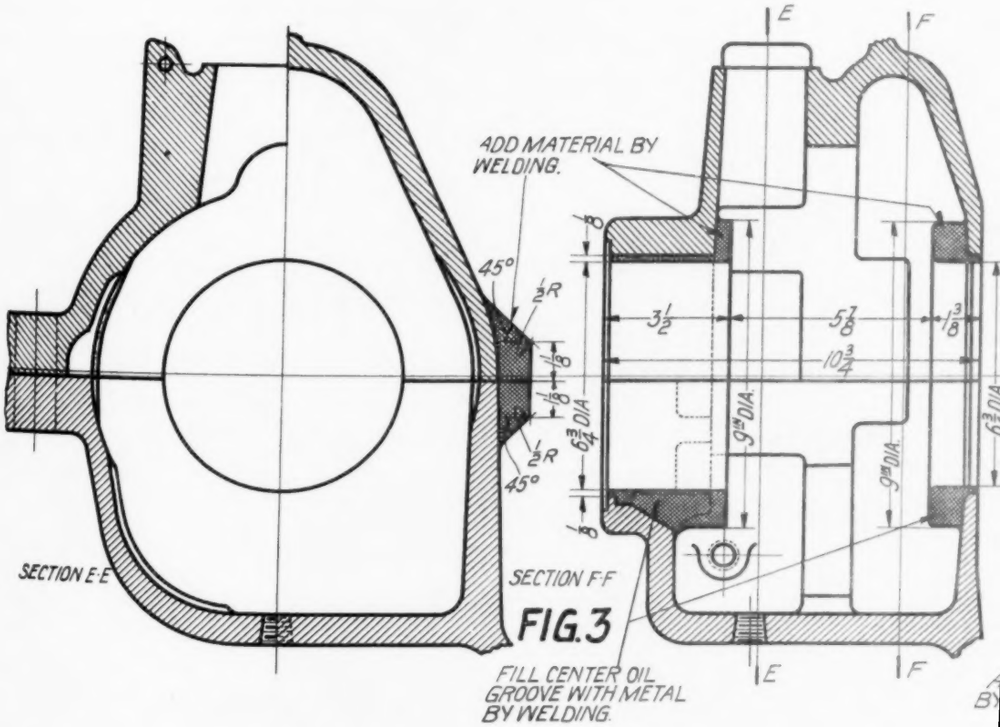

ADD MATERIAL BY WELDING.
SECTION E-E
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING.

FIG. 3

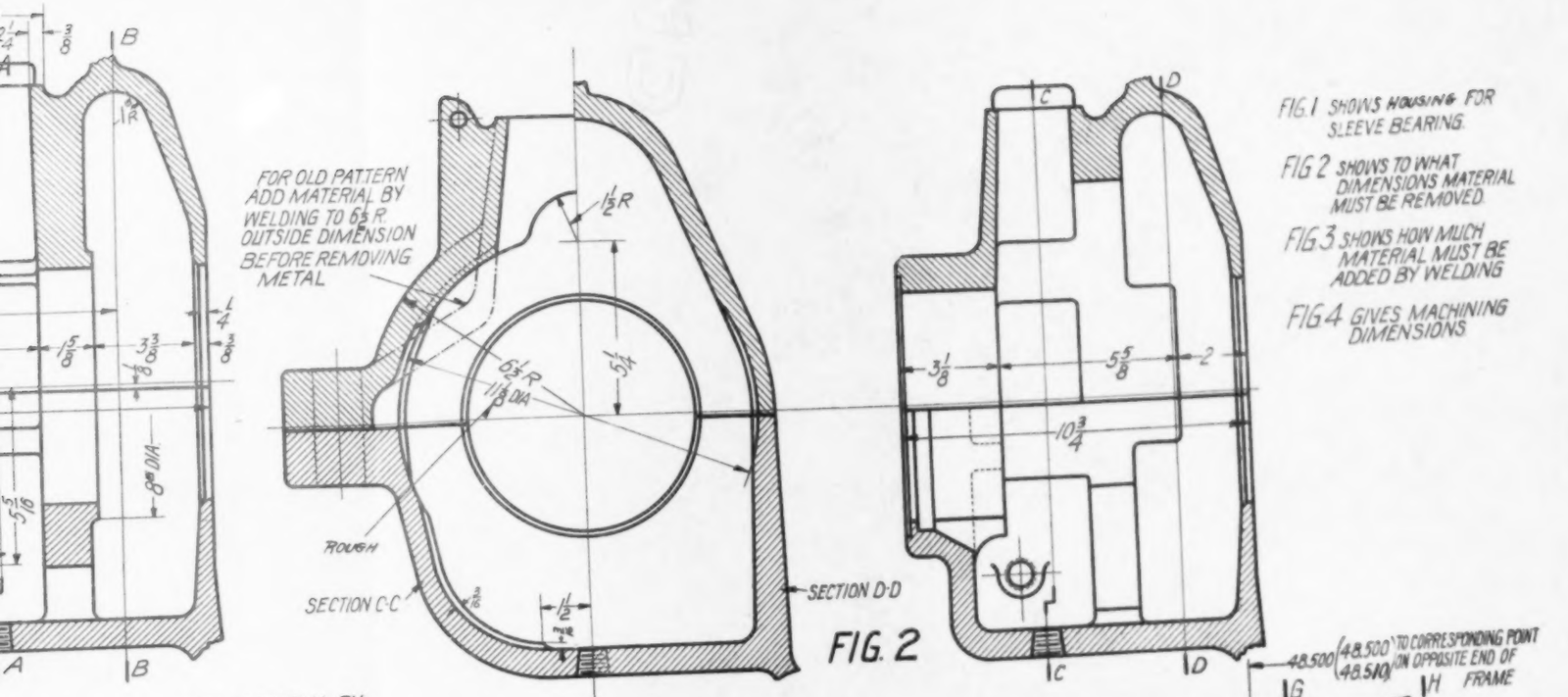


FIG. 2

FIG. 1 SHOWS HOUSING FOR SLEEVE BEARING.

FIG. 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED.

FIG. 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING

FIG. 4 GIVES MACHINING DIMENSIONS

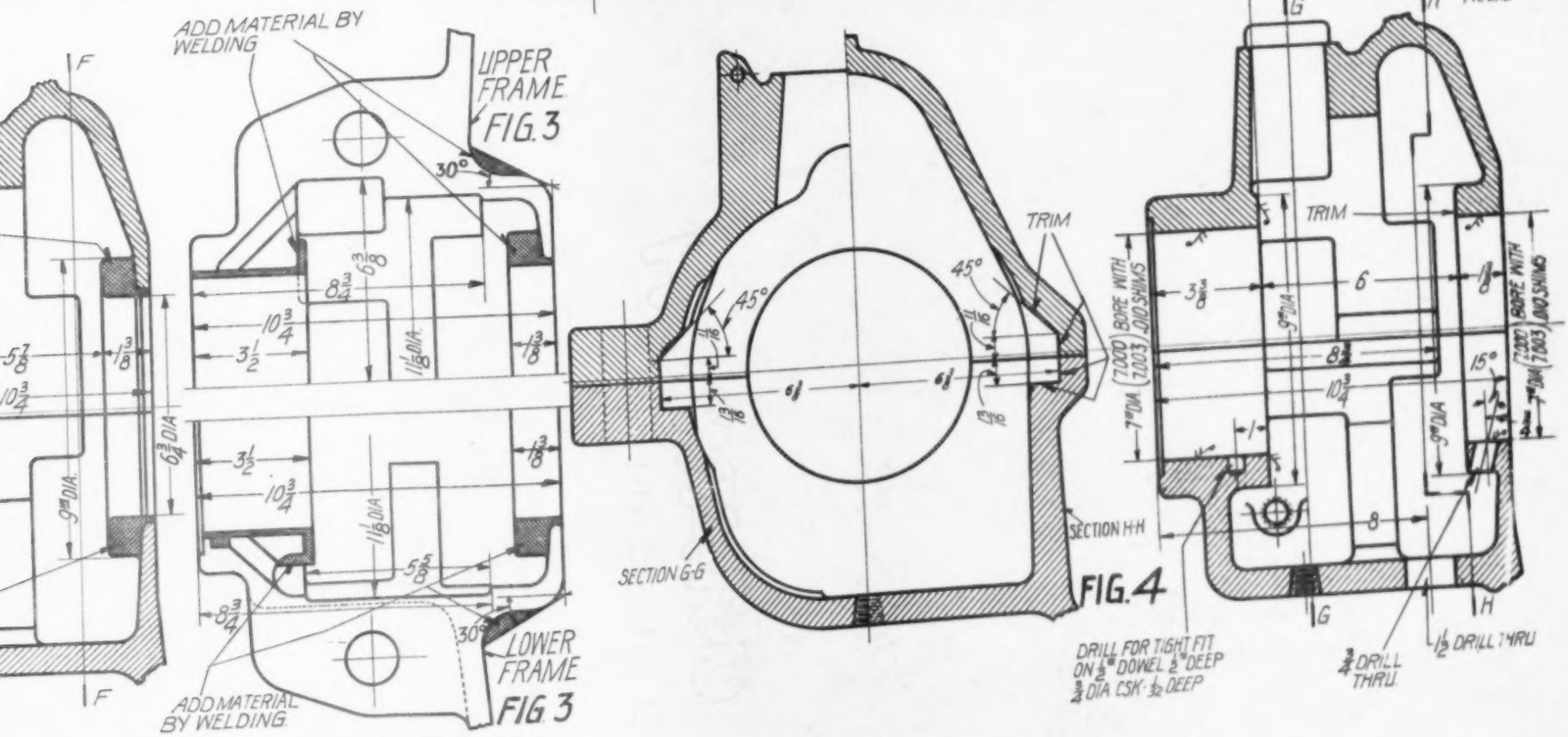


FIG XVIII

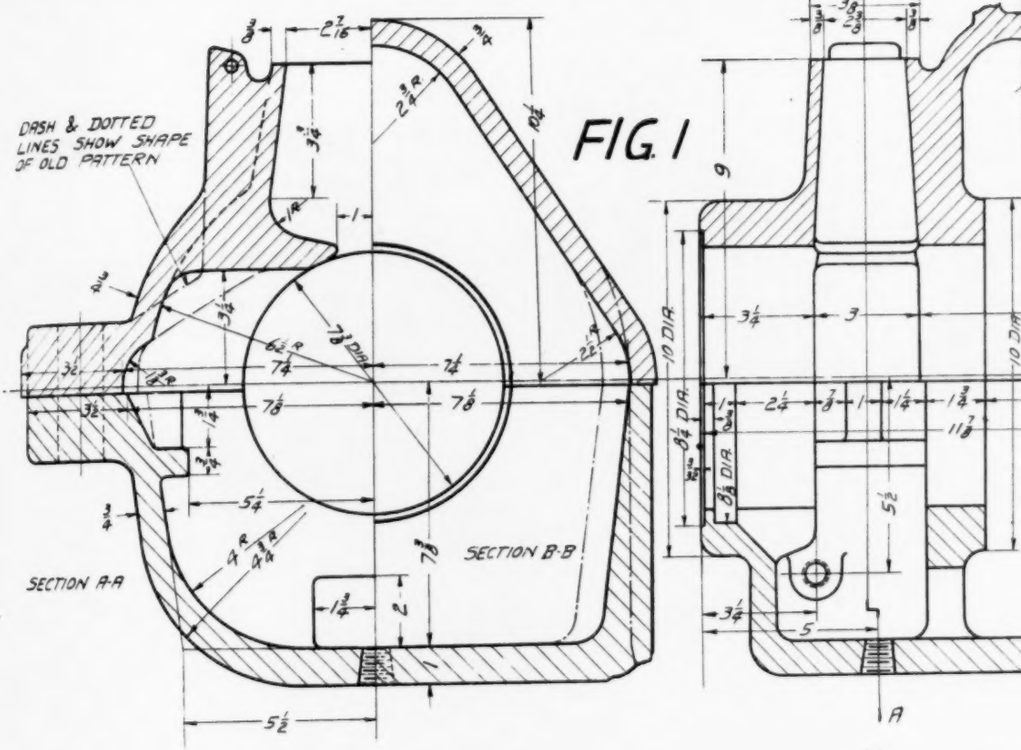

DASH & DOTTED LINES SHOW SHAPE OF OLD PATTERN
SECTION A-A
SECTION B-B
10 DIA
9
3
5
A

FIG. 1

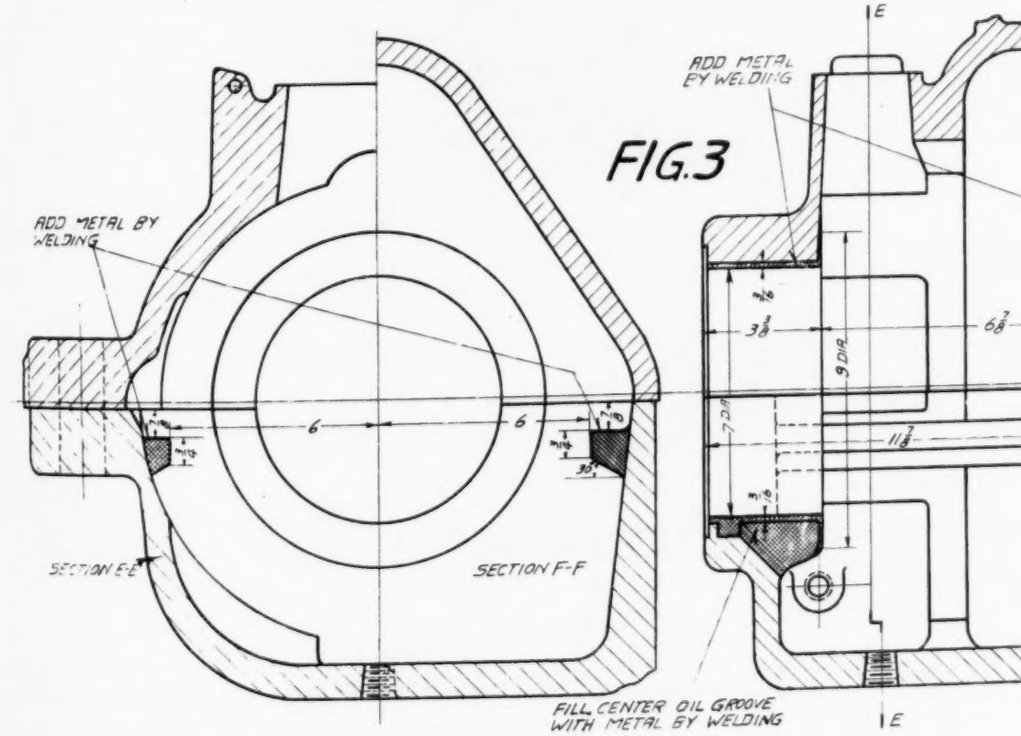

ADD METAL BY WELDING
ADD METAL BY WELDING
SECTION E-E
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING
9 DIA
6
E

FIG. 3

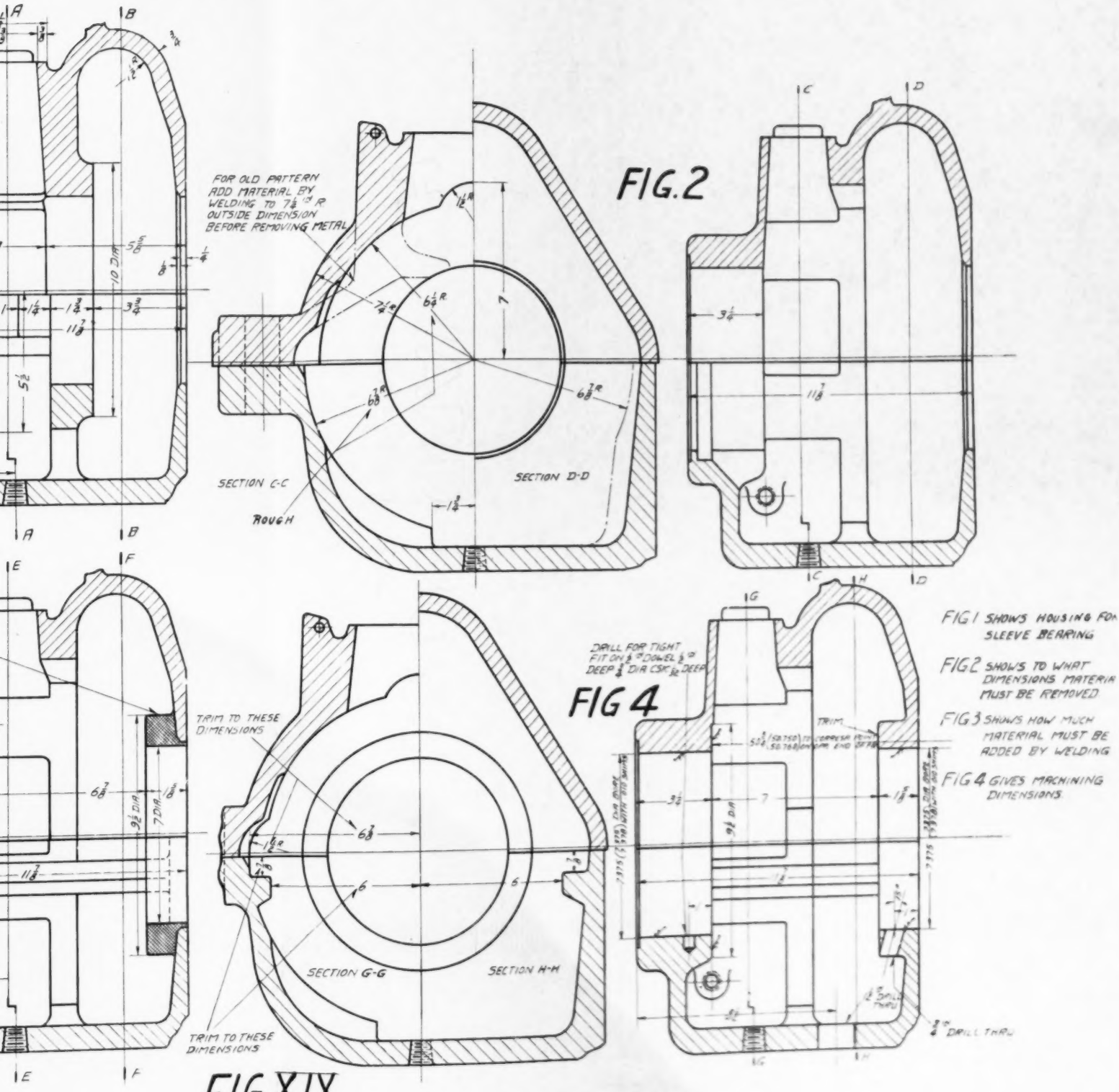


FIG. 2

FIG 4

FIG 1 SHOWS HOUSING FOR SLEEVE BEARING

FIG 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED

FIG 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING

FIG 4 GIVES MACHINING DIMENSIONS

FIG XIX

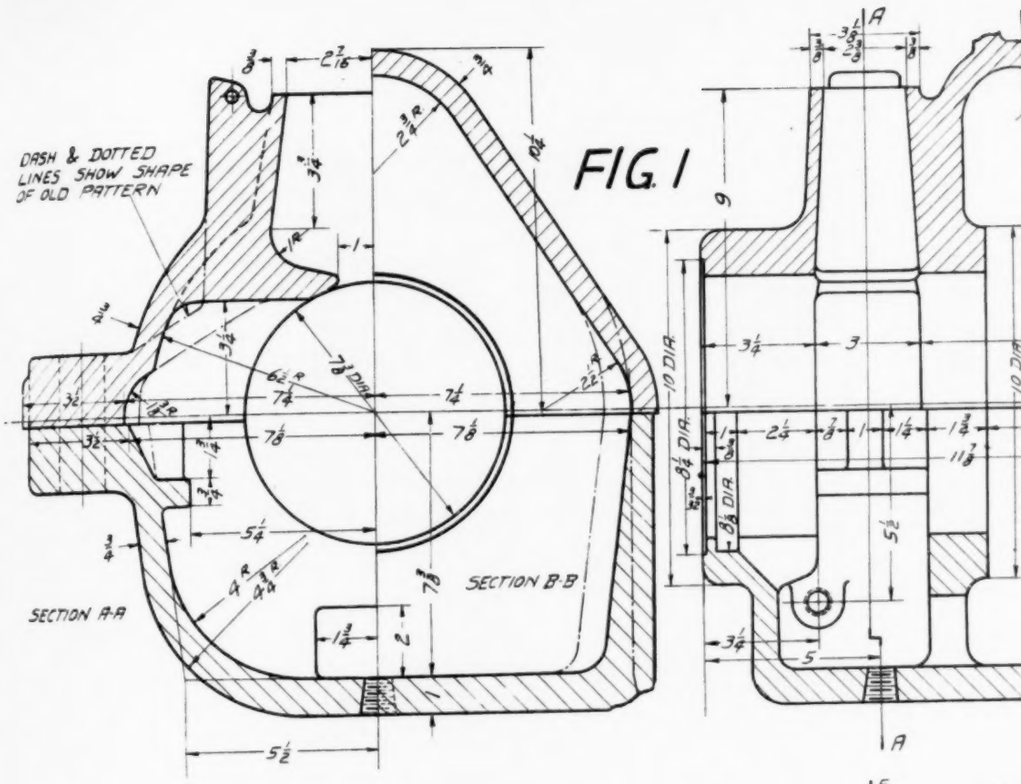

DASH & DOTTED LINES SHOW SHAPE OF OLD PATTERN
SECTION A-A
SECTION B-B
A
A

FIG. 1

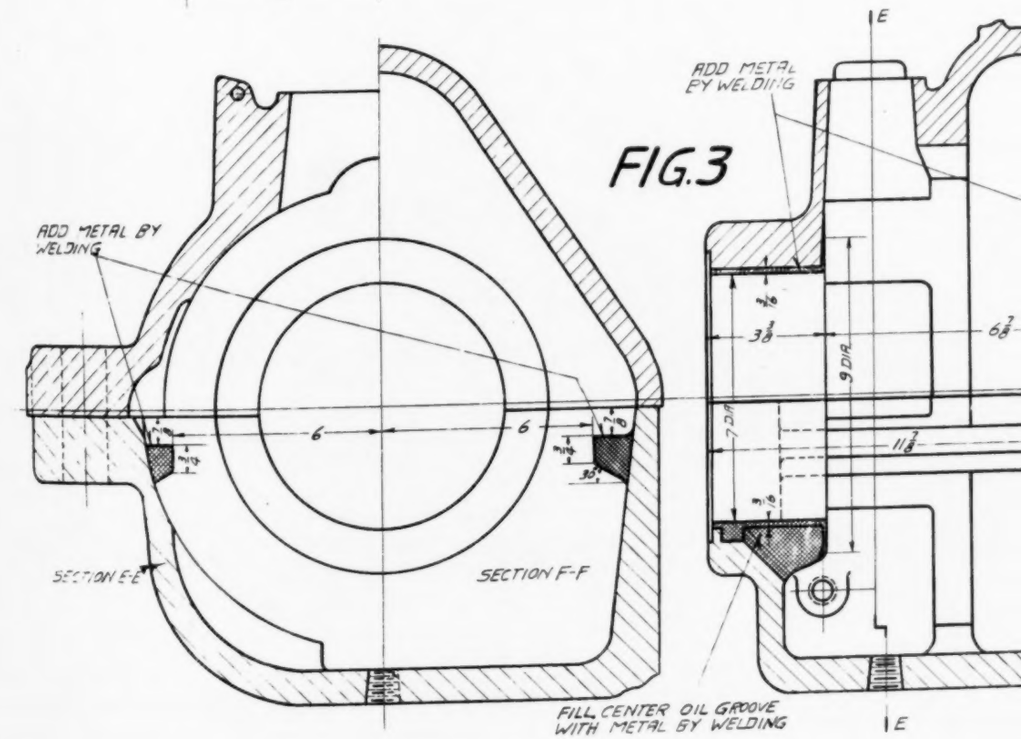

ADD METAL BY WELDING
ADD METAL BY WELDING
SECTION E-E
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING
E
E

FIG. 3

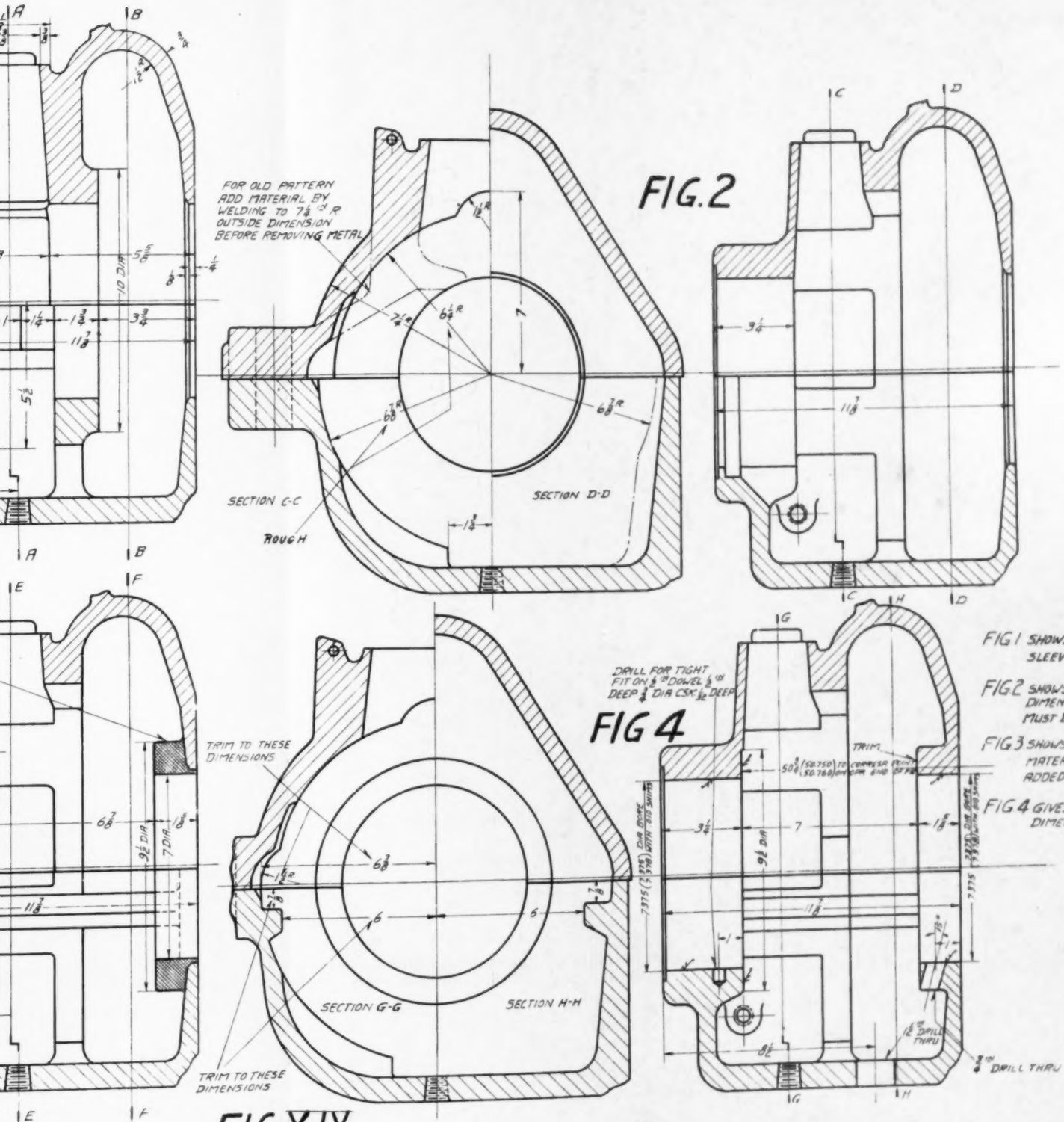

FOR OLD PATTERN ADD MATERIAL BY WELDING TO 7 1/8" R OUTSIDE DIMENSION BEFORE REMOVING METAL
SECTION C-C
ROUGH
SECTION D-D
TRIM TO THESE DIMENSIONS
SECTION G-G
SECTION H-H
TRIM TO THESE DIMENSIONS
DRILL FOR TIGHT FIT ON 1/2" DOWEL 1/2" DEEP 3/4" DIA CSK 1/2" DEEP
TRIM
1/2" DRILL THRU
3/8" DRILL THRU

FIG. 2

FIG 4

FIG 1 SHOWS HOUSING FOR SLEEVE BEARING

FIG 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED

FIG 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING

FIG 4 GIVES MACHINING DIMENSIONS

FIG XIX

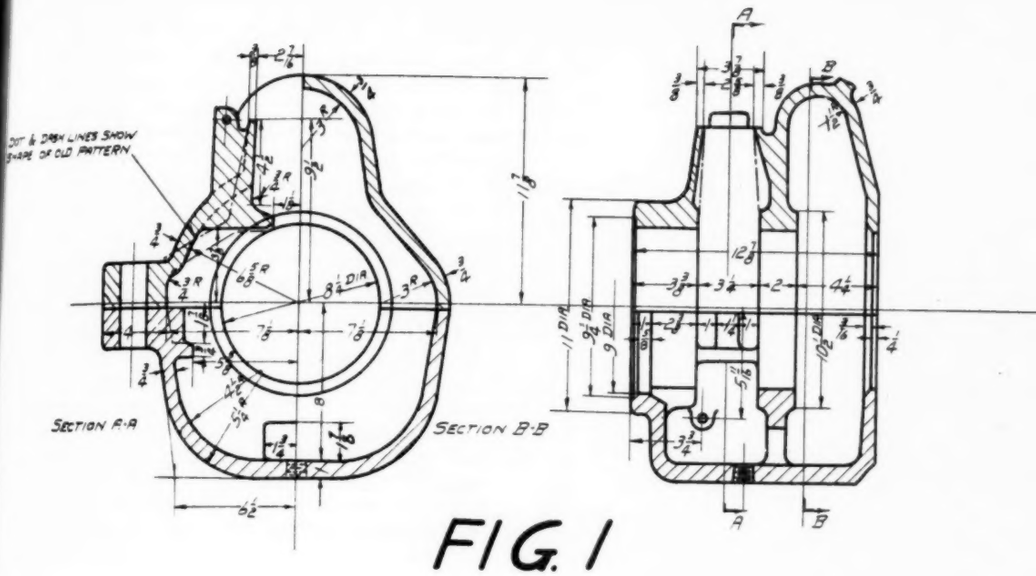

DOT & DASH LINES SHOW SHAPE OF OLD PATTERN
SECTION A-A
SECTION B-B

FIG. 1

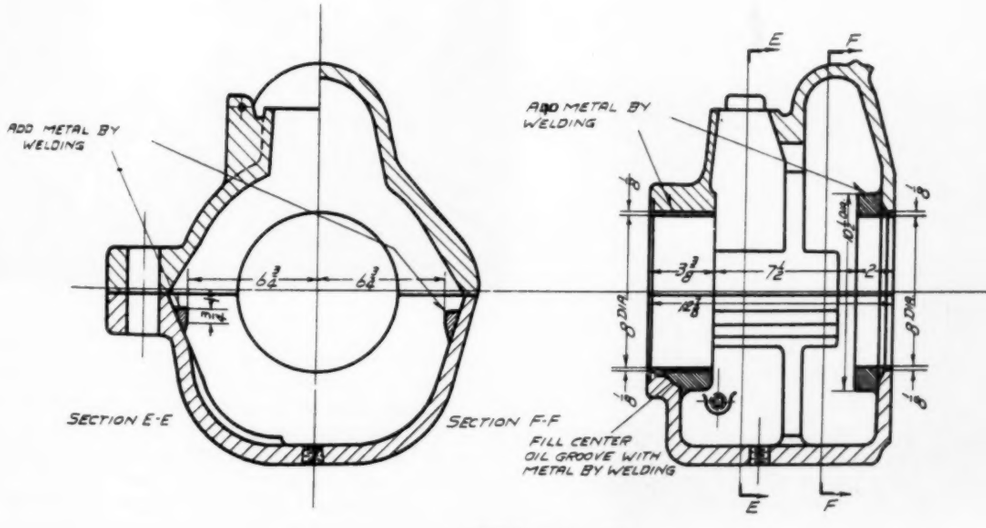

ADD METAL BY WELDING
SECTION E-E
ADD METAL BY WELDING
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING

FIG. 3

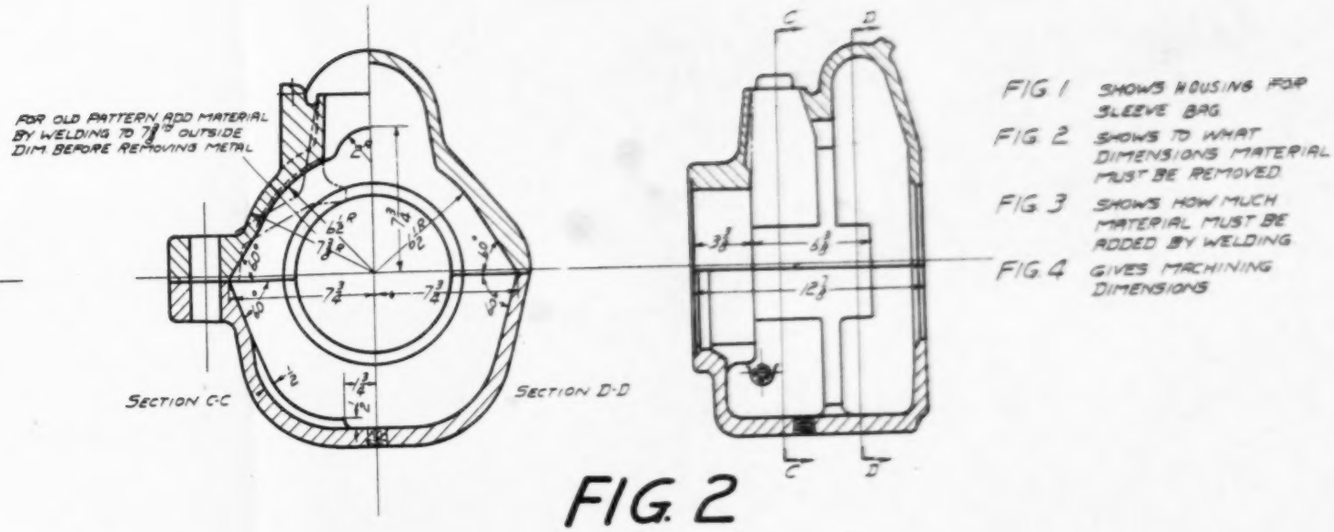


FIG. 1 SHOWS HOUSING FOR SLEEVE BAG.

FIG. 2 SHOWS TO WHAT DIMENSIONS MATERIAL MUST BE REMOVED.

FIG. 3 SHOWS HOW MUCH MATERIAL MUST BE ADDED BY WELDING

FIG. 4 GIVES MACHINING DIMENSIONS

FIG. 2

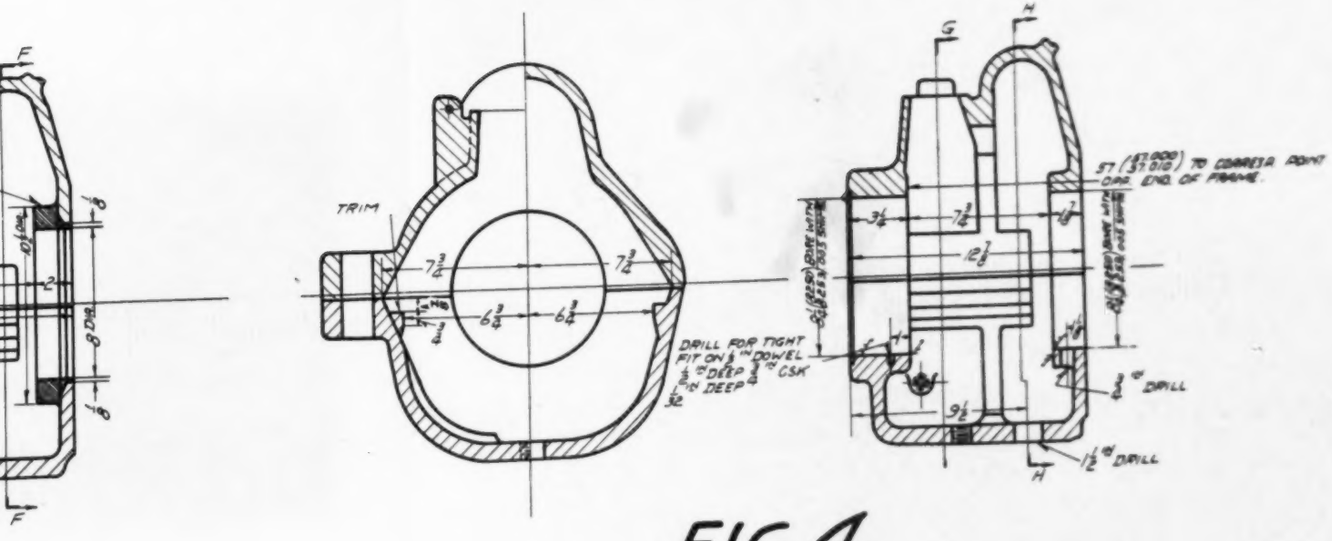


FIG. 4

FIG. XX

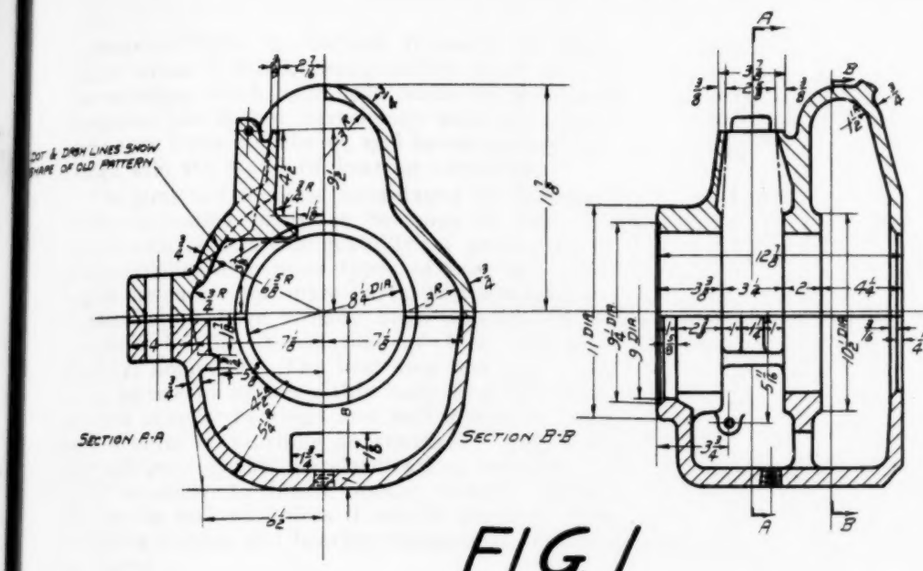

DOT & DASH LINES SHOW SHAPE OF OLD PATTERN
SECTION A-A
SECTION B-B

FIG. 1

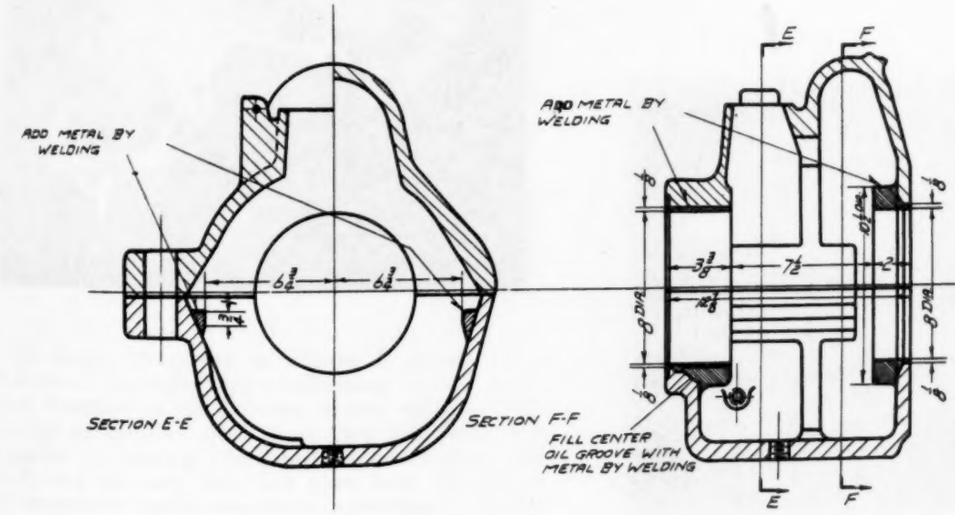

ADD METAL BY WELDING
SECTION E-E
ADD METAL BY WELDING
SECTION F-F
FILL CENTER OIL GROOVE WITH METAL BY WELDING

FIG. 3

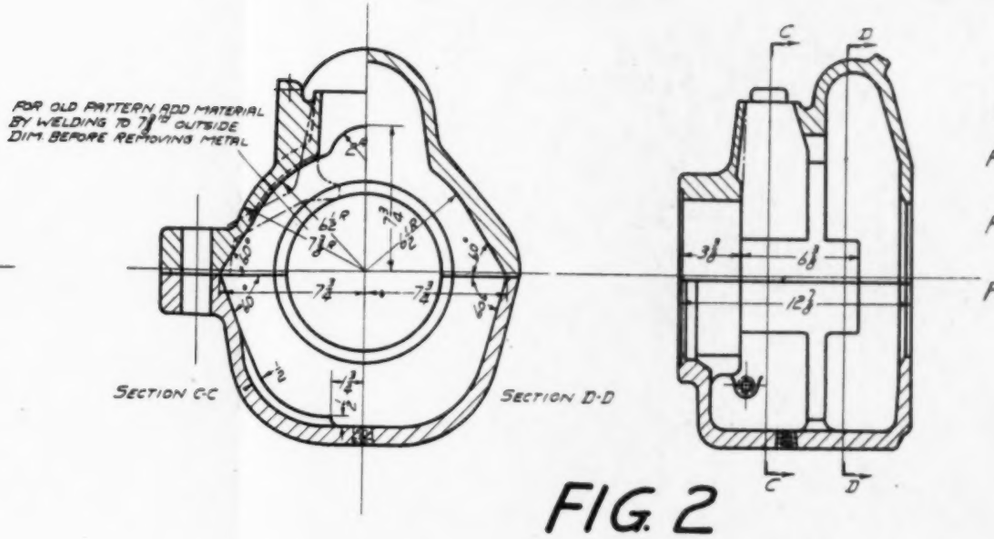


FIG. 1 SHOWS HOUSING FOR SLEEVE BAG.

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FIG. 4 GIVES MACHINING DIMENSIONS.

FIG. 2

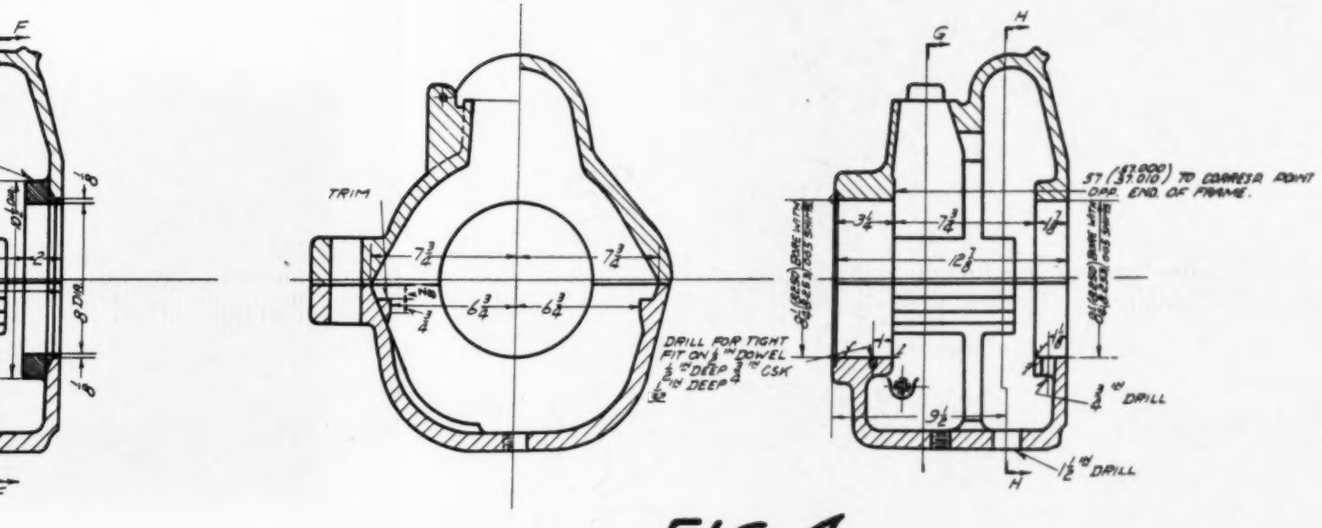
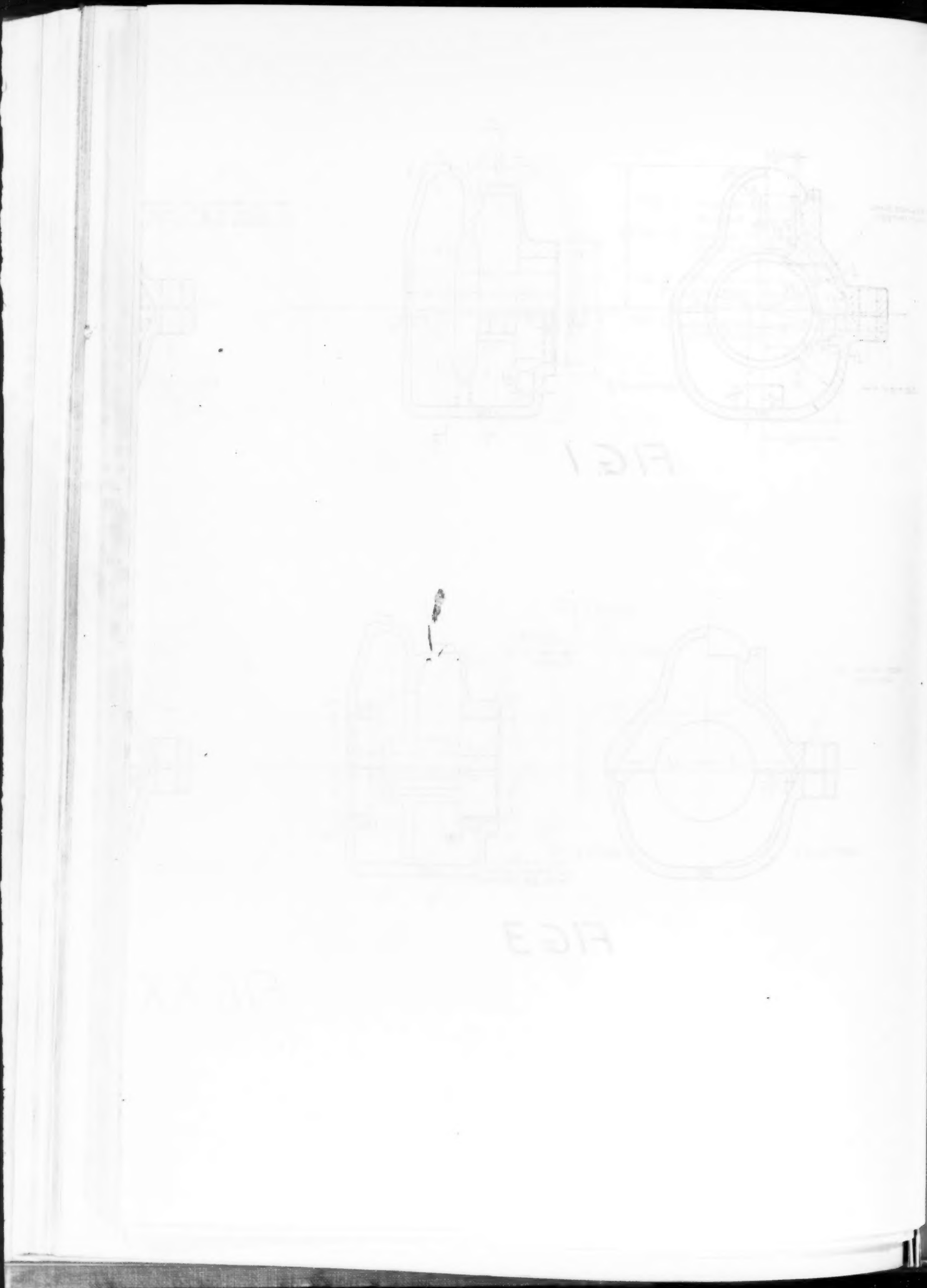


FIG. 4

FIG. XX



as shown in Figure I. Indeed, it would be impossible to secure such interchangeability, since the various cartridges which have been made for the special changeover jobs do not interchange with one another in the same frame machining, and hence cannot interchange with the standard bearing cartridge.

The great and obvious advantages of uniformity in the application of roller bearings to mill type motors, such as interchangeability of armatures, interchangeability of various types of bearings, reduction in the number of spare parts, and simplification of manufacture, have already been appreciated and recognized by the Association of Iron and Steel Electrical Engineers. The first step has been taken in the agreement between this body and the manufacturers of roller bearings and mill motors to adopt the 300 series of bearings as standard. The maximum efficiency of this standardization, intended primarily to apply to future motor designs, cannot, however, be realized unless it can be made to apply to existing designs and bearing changeovers in existing motors.

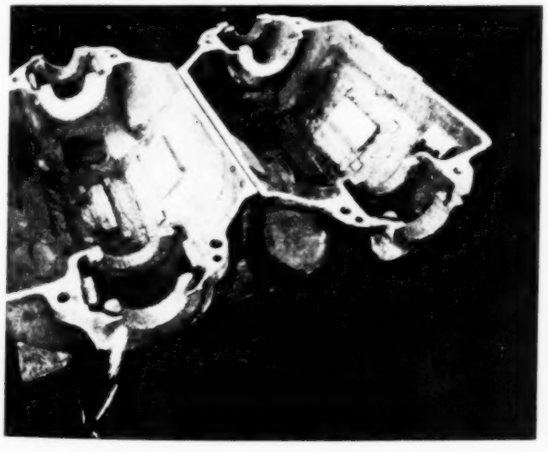


FIG. V.

The design illustrated in Figure I. employs the 300 series of bearings, thus conforming to the Association Standard in an existing motor design. The following paragraphs show how this Standard may be applied to bearing change-overs in existing MC motors, and not only this, but also, how the resulting changeover parts—bearings, cartridges, frames and armatures may be exactly interchangeable with similar parts of new motors having roller bearings incorporated in their design.

Each step in the modification of a 50 MC sleeve bearing frame to adapt it for the installation of the standard roller bearings, is separately illustrated in Figures III. to X., in order to give a clear understanding of the work which is necessary to change-over an existing sleeve bearing motor.

Figures III. and VII. show the upper and lower halves of a standard 50 MC mill motor frame designed for sleeve bearings. It is to be noted that there is a central support in each bearing housing to carry the inner end of the sleeve bearing. This support must be cut away to accommodate the roller bearing cartridge. Figures IV. and VIII. show the same frame after the central supporting web and other irregular projections which would interfere with the roller bearing housing have been cut away by the oxy-acetylene flame. Note from Figure VIII. that it may be necessary to add some material at certain points by electric welding before the unnecessary parts are cut away.

Figures V. and IX. show the frame after material has been added by electric arc welding to provide adequate support for the roller bearing cartridge. This material is added by welding after the unnecessary portions of the sleeve bearing housing have been cut away. Figures VI. and X. show the frame after it has been machined to accommodate the roller bearing cartridge. It is to be noted that this machined frame is now exactly interchangeable with similar frames specially designed for roller bearings only. Figure XI. shows a standard roller bearing and cartridge mounting in the housing, modified as indicated in Figures III. to X. inclusive.

The following data show the actual time consumed in making modifications to the 50 MC frame as outlined above, and indicate the work required to change-over a representative size motor.

Burning	.....	2½ hours
Welding	.....	14 hours
Machining	.....	3 hours
Total	.....	19½ hours

In applying roller bearings to existing sleeve bearing motors, it is also necessary to machine the sleeve bearing shaft to make it suitable for use with

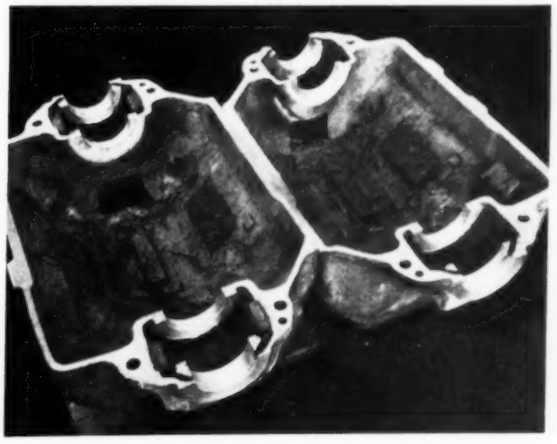


FIG. VI

the standard roller bearings. Figure XII. shows at "A" a sleeve bearing shaft for a MC-50 frame motor, and at "B" shows how this shaft must be modified for use with roller bearings, and also shows the spacer sleeves which are necessary.

Figures III. to XII. inclusive, show in detail the several steps in the process of modifying a frame MC-50 motor. Working drawings have also been made up for the other sizes from frame 20 to frame 103, and these are shown by Figures XIII. to XX. inclusive.

Figure XIII. shows the detailed dimensions required for reference in producing MC roller bearing shafts from existing sleeve bearing shafts in all frame sizes. It is to be noted that, in the case of the MC-

30, a sleeve or bushing must be used to increase the diameter of the shaft under the roller bearing or else an entirely new shaft must be made. Also, in the roller bearing design, the MC-103 shaft is the same as the MC-100 shaft. The rear shaft extension is reduced accordingly.

Complete information for modifying sleeve bearing frames to suit roller bearing cartridges are shown for all frame sizes from 20 to 103 in Figures XIV. to XX. inclusive.

Those users of Type MC mill motors who have made a limited number of bearing changeovers using one of the non-interchangeable methods, will be interested to know that in most cases these changeovers can be converted into the standard interchangeable design with practically the same effort as is required to modify a frame from the sleeve bearing design. Thus, if desired, existing sleeve bearing motors and non-interchangeable roller bearings can be converted to the standard design, and thus be entirely interchangeable with the standard roller bearing motors now being manufactured.

With the rapid expansion in the use of gas flame cutting and electric arc welding in the construction of new machines and structures, it is interesting to note that the frame modifications described in the foregoing, although somewhat elaborate, are reduced to comparative simplicity by these modern manufacturing methods.

Items of Interest

Mr. J. J. Mellon, formerly of Pittsburgh, Pa., has joined the home office force of The Clark Controller Company of Cleveland, Ohio, in the capacity of Sales Engineer.

The Ohio Electric & Controller Company, Cleveland, Ohio, announce the appointment of Mr. J. W. Rumely, as their Chicago District Sales Manager, Motor Department, 333 North Michigan Avenue, effective June 1st.

The Pittsburgh office of The Brown Instrument Company has moved to larger quarters. It is now located at 1522 Oliver Building. While the former office was also located in the Oliver Building, the new quarters offer increased facilities for handling the new business.

On May 3rd, Appleton Electric Company, 1701-29 Wellington Avenue, Chicago, Ill., purchased from the Jefferson Electric Company of Chicago the complete Powerlet Line, including Threaded and Threadless Conduit Fittings as well as the complete line of Powerlet Entrance Fittings and everything pertaining to these lines.

Mr. H. W. Young, President of the Delta-Star Electric Company, Chicago, Ill., sailed in June on the Majestic, and will visit the Delta-Star European connections. He will also present a paper on Outdoor Substations at the International High Voltage Conference to be held at Paris.

F. H. Willcox, Vice President of the Freyn Engineering Company, Chicago, Illinois, returned July 2 on the Steamship Homeric from a six weeks' business trip in England, in connection with consulting work for the Ford Motor Company.

Effective July 1st, Mr. R. N. Jessop, formerly District Sales Manager of The Ohio Electric & Controller Company Motor Department, 333 North Michigan Boulevard, Chicago, Illinois, has been appointed Sales Engineer with office at the factory, Cleveland, Ohio.

Beginning May 14th, 1929, the direction and control of the Sales and Service Division of the Pyle-National Company, Chicago, Illinois, will be placed in the hands of Mr. J. A. Amos, whose title will be Vice President in Charles of Sales and Service.

Standard Underground Cable Company, Division of General Cable Corporation, announce the discontinuance of their Construction or Cable Installation Department, as of July 1, 1929. Cable installation has been a continuing feature with the Standard for nearly forty years, during which time, however, there has been a gradual building up of installation and maintenance departments by all of the larger cable users. This, together with the service which qualified contractors are prepared to supply, renders no longer so necessary the maintenance by the manufacturer of a service which was for a long time an outstanding essential.

ACCIDENT PREVENTION ON CRANE RUNWAYS

Accident prevention on crane runways is a big problem in the Steel Industry, especially where more than one crane is on the runway. The Nichols-Lintern Company of Cleveland, Ohio, have developed a new double lantern which is meeting with the general approval of steel mill safety engineers.

The complete system, which can be readily installed on any crane, consists of the double lantern (red and green fresnel) and a special switch developed for the purpose. The switch has no neutral point showing either a red or green light at all times. Lamp changes can be easily made and safety chains prevent the dropping of parts or lenses when changes are being made.

When repairmen go out on the crane they throw the light switch which lights the red light. The red light indicates the crane must not be moved under any circumstance, and gives the repairmen the opportunity to do their work in a safe manner and assures a better job being done. The green light indicates crane can be moved without

investigation or warning by another crane. No light, is to be investigated before crane is moved.

Another application of the double lantern consists of 2 red fresnels which are lighted only when crane is being repaired. No signal is visible when the crane is in operation.

OVERLOAD TEST ON ARC-WELDED CRANE GIRDERS

The Cleveland Crane and Engineering Company, Wickliffe, O., has recently completed an overhead traveling crane of 10-ton capacity and 80-foot span with the bridge girders as well as the trolley and end trucks completely arc-welded.

One of the bridge girders was tested for deflection. Since the rated capacity of this crane is 10 tons, each girder must carry a live load of 5 tons plus one-half of the weight of the trolley, the total weight of which is 6 tons.

In the test each girder was subjected to a test load of 16 tons or exactly 100% overload. The deflection was one-half inch—slightly less than the normal deflection under similar conditions for a bridge girder of ordinary riveted construction. While this company has built several cranes with all arc-welded girders including some for heavy duty steel mill service, it is believed that this 80-foot span crane is the longest to be made in this manner up to the present date.

SOUTH MANCHURIA RAILWAY COMPANY BUYS BURNERS

The American Heat Economy Bureau, Inc., have been awarded the contract for Steinbart Burners for all Stoves and Boilers for three blast furnaces at the Anzan Steel Works of the above company. Altogether 22 Steinbart Burners will be installed.

DUST TIGHT ENCLOSURES FOR CUTLER-HAMMER STARTERS

The development of dust-tight enclosing cases for their across-the-line automatic starters, is announced by Cutler-Hammer, Inc., 157 Twelfth street, Milwaukee, Wis.

These new enclosures are built in two types: For motors up to 5 HP., the case is of cast-iron and for larger sizes it is made of heavy welded boiler plate. They are provided with a soft Para rubber gasket between the cover and case. Eye bolts with wing nuts at the sides, hold the cover tight. In addition to being dust-tight, the small cast-iron enclosure is also weatherproof. It has the start, stop and reset buttons mounted directly in the cover. The larger sizes have the reset button only in the cover and a separate dust-tight pushbutton station provides remote control.

The new dust-tight equipment will not replace Cutler-Hammer's standard dust-proof enclosures, but is to be offered as an option for installation in mines, woodworking plants, cement mills, flour mills, pulverizing plants and other industries where the large amount of dust in the air may interfere with the efficient operation of the starter.

LARGE STEEL PLANT ORDER RECEIVED BY WESTINGHOUSE

The Youngstown Sheet & Tube Company has recently placed an order with the Westinghouse Electric & Manufacturing Company for apparatus amounting to about $550,000. This equipment covers the motors and control for use in driving a 10" and a 14"-18" merchant mill to be installed in the Indiana Harbor Works of the Company.

The 10" merchant mill will use six d-c. motors as follows: One motor rated at 1400/900 hp. on the roughing stand, a 1500 hp. motor on the intermediate rougher, three 500 hp. motors on the intermediate finisher and one 1500 hp. driving the finishing stand. The 14"-18" merchant mill will have a 5600 hp. motor which will drive roughing stands from both ends of an extended shaft. Two 1500 hp. motors drive the finishing stands.

Three 4000 kw. synchronous motor-generator sets will supply power to the motors. Each m-g. set consists of four units including a 5700 hp. synchronous motor coupled to two 1500 kw. 600 volts d-c. generator, and a 1000 kw. 250 volt d-c. generator.

The switching equipment for all this apparatus is of the vertical-lift truck, compound-filled type. Control for the motors is all magnetic type, the 5600 hp. motor having variable voltage control. A-c. power for the operation of the motors of the m-g. sets is obtained partly from the Commonwealth Edison Company and partly from the power house of the plant itself.

NEW PUBLICATION

The water works system of the City of Toronto, Ont., which is now being extended by a $14,000,000 addition, is briefly described, particularly the pumping equipment, in a leaflet distributed by the De Laval Steam Turbine Company, Trenton, N. J. Altogether, there are 14 large De Laval centrifugal pumps in the several pumping stations, six being driven by geared steam turbines and the others by electric motors using Niagara power. Their aggregate daily capacity is approximately 325,000,000 Imp. gallons, representing about 12,000 water hp. A number of these pumps have, on the acceptance tests, made new records for high efficiency.

BENJAMIN ANNOUNCES CATALOG SUPPLEMENT

Benjamin Electric Manufacturing Company, Des Plaines, Illinois,, has published Supplement Number One to Catalog 24. Supplement contains complete descriptions, listings, illustrations and much installation data on the following recent additions to the Benjamin line: Sign Reflector, New Type 79 Glasteel Diffuser, Sturdox Fixtures, Removable Reflector Holders, Vapor-Proof Projectolite, Intensifier, Portable Inspection-Lite, New Dust Tight Glass Cover, Concentrating Type Unit, Gymnasium Fixture, 45 Degree Ball Fixture Alignor, Motor-Driven Signal, New Super-Sensitive Relay, and the Stand Lamp Vase Adapter.

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BALTIMORE, MD.

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PRODUCTS

Complete Plants for Coal and Water Gas, Coal Gas By-Products; Special Equipment for Gas and By-Product Plants; Special Gas Cleaning Apparatus; Genter Type Thickener; B. H. Co. Westling Valve; Fast Flexible Couplings; Waterless Gas Holders.

B. H. CO. WESTLING VALVE

(Patent Applied For)

The B. H. Co. Westling Valve is an all-metal, positive shut-off valve of the goggle plate type for use primarily in producer and blast furnace gas mains where the gas carries large quantities of dust and may be at temperatures up to 1000° F.

The valve consists of a rolled steel goggle plate one half of which is solid, the other having an opening the size of the gas main. This plate is pivoted between two cast steel girder type frames of special design having machined faces.

The joints between the faces of the frames and the goggle plate are made gas tight by clamping the frames on the plate at high pressure by means of three simultaneously operated differential screws. The valve is complete as shipped ready to be bolted in the main and requires no supports, foundations, piping, wiring or any other auxiliary devices.

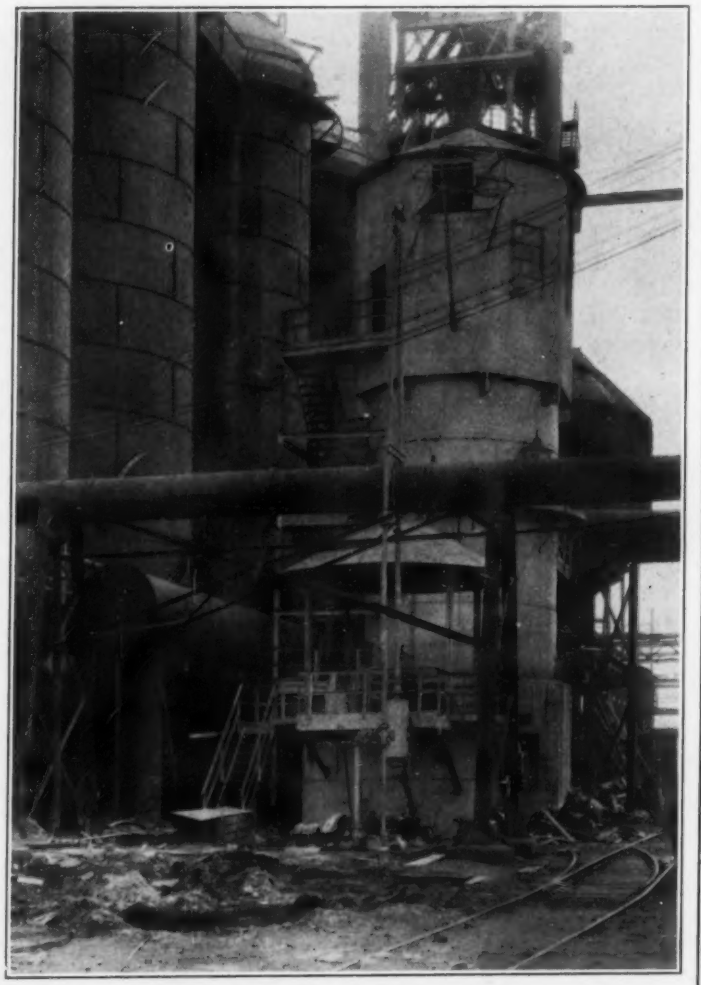
B. H. CO. THICKENER (GENTER TYPE)

The B. H. Co. Genter Type Thickener is a filter-thickener wherein the solids are primarily removed from suspension by filtration, i.e., the clear liquid is passed through a filter medium which retains the suspended solids on its exterior and these solids are then removed in cake form, periodically and automatically, into the mixture being thickened and the thickened sludge is removed by revolving rakes and gravity through a mud line at the bottom of the thickener tank. The outstanding advantages of this thickener are higher concentration with clear filtrate, compact and accessible design, small amount of liquid in process, flexible operation, reserve capacity, high heat conservation, low installation cost.

B. H. CO. VERTICAL CENTRIFUGAL GAS SCRUBBERS (FELD TYPE)

For dust removal from Blast Furnace Gas, recovery of gasoline, benzol, etc., from gas.

Scrubbers built with size and number of sections to suit any requirements.



B. H. CO. VERTICAL CENTRIFUGAL SCRUBBER (FELD TYPE)
For wet cleaning of 100,000 cu. ft. per minute of blast furnace gas with B. H. Co. thickener (Genter Type) in foreground for handling of heavy effluent from scrubber.